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Pursuant to 37 CFR 1.53(b), transmitted herewith for filing is the patent application of

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Yasuo KOSHIZUKA

Title: "PHOTOSENSOR SYSTEM AND DRIVE CONTROL METHOD THEREOF"

Priority Claim (35 U.S.C. 119) is made, based upon:

Japan No. 11-316650 November 8, 1999
Japan No. 11-319605 November 10, 1999
Japan No. 2000-015981 January 25, 2000

Enclosed herewith are:

[X] Specification (Description, Claims, Abstract): Pages 1 - 86 ; Number of claims 1 - 25
[X] Declaration and Power of Attorney [X] executed; [ ] unexecuted (supplied for information purposes)
[X] 33 Sheets of drawings, Figures 1 - 33D [X] Formal [ ] Informal
[X] Assignment and "Patents" Recordation Form Cover Sheet (PTO-1595) AND $40. RECORDATION FEE.
[X] Certified copy (ies) of priority document(s) identified above
[X] Information Disclosure Statement; [X] Form PTO-1449
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Total Claims	25	-20	=	5	x $18.00	=	$ 90.00
Independent Claims	2	- 3	=	0	x $80.00	=	$
MULTIPLE DEPENDENT CLAIMS					+ $270.00	=	$
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To the extent not tendered by check, authorization is given to charge any fees under 37 CFR 1.16 and 1.17 during pendency of the application, or to credit any overpayment, to Deposit Account No. 06-1378. Duplicate copy of this letter is enclosed.

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TITLE OF THE INVENTION

PHOTOSENSOR SYSTEM AND DRIVE CONTROL METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Applications No. 11-316650, filed November 8, 1999; No. 11-319605, filed November 10, 1999; and No. 2000-015981, filed January 25, 2000, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to a photosensor system having a photosensor array constituted by two-dimensionally arraying a plurality of photosensors, and a drive control method thereof.

Imaging apparatuses such as electronic still cameras, video cameras, and the like have come to be very widely used. These imaging apparatuses employ a solid-state imaging device, such as a CCD (Charge Coupled Device), which serves as a photoelectric converting device for converting an image of a to-be-photographed subject into an image signal. As well known, the CCD has a structure in which photosensors (light receiving elements) such as photodiodes, or thin film transistors (TFT: Thin Film Transistor) are arranged in a matrix, and the amount of electron-hole pairs (the amount of charge) generated corresponding to the amount of light entering the light receiving

section of each sensor is detected by a horizontal scanning circuit and vertical scanning circuit to detect the luminance of radiation.

In a photosensor system using such a CCD, it is necessary to respectively provide scanned photosensors with selective transistors for causing the scanned photosensor to assume a selected state. In place of the combination of the photosensor and the selective transistor, a photosensor (to be referred to as a double-gate photosensor hereinafter) is now being developed, which is formed of a thin film transistor having a so-called double-gate structure and has both a photosensing function and a selecting function.

FIG. 31A is a sectional view showing the structure of a double-gate photosensor 10. FIG. 31B is a circuit diagram showing the equivalent circuit of the double-gate photosensor 10.

The double-gate photosensor 10 comprises a semiconductor thin film 11 formed of amorphous silicon or the like, n^+-silicon layers 17 and 18, source and drain electrodes 12 and 13 respectively formed on the n^+-silicon layers 17 and 18, a top gate electrode 21 formed above the semiconductor thin film 11 via a block insulating film 14 and upper gate insulating film 15, a protective insulating film 20 provided on the top gate electrode 21, and a bottom gate electrode 22 provided below the semiconductor thin film 11 via

a lower gate insulating film 16. The double-gate photosensor 10 is provided on a transparent insulating substrate 19 formed of glass or the like.

In other words, the double-gate photosensor 10 includes an upper MOS transistor comprised of the semiconductor thin film 11, source electrode 12, drain electrode 13, and top gate electrode 21, and a lower MOS transistor comprised of the semiconductor thin film 11, source electrode 12, drain electrode 13, and bottom gate electrode 22. As is shown in the equivalent circuit of FIG. 31B, the double-gate photosensor 10 is considered to include two MOS transistors having a common channel region formed of the semiconductor thin film 11, TG (Top Gate terminal), BG (Bottom Gate terminal), S (Source terminal), and D (drain Terminal).

The protective insulating film 20, top gate electrode 21, upper gate insulating film 15, block insulating film 14, and lower gate insulating film 16 are all formed of a material having a high transmittance of visible light for activating the semiconductor thin film 11. Light entering the sensor from the top gate electrode 21 side passes through the top gate electrode 21, upper gate insulating film 15, and block insulating film 14, and then enters the semiconductor thin film 11, thereby generating and accumulating charges (positive holes) in the channel region.

FIG. 32 is a schematic view showing a photosensor system constituted by two-dimensionally arraying double-gate photosensors 10. As shown in FIG. 32, the photosensor system comprises a sensor array 100 that is constituted of a large number of double-gate photosensors 10 arranged in an n $\times$ m matrix, top and bottom gate lines 101 and 102 that respectively connect the top gate terminals TG and bottom gate terminals BG of the double-gate photosensors 10 in a row direction, top and bottom gate drivers 111 and 112 respectively connected to the top and bottom gate lines 101 and 102, data lines 103 that respectively connect the drain terminals D of the double-gate photosensors 10 in a column direction, and an output circuit section 113 connected to the data lines 103.

In FIG. 32, ϕtg and ϕbg represent control signals for generating a reset pulse ϕTi and readout pulse ϕBi, respectively, which will be described later, and ϕpg represents a pre-charge pulse for controlling the timing at which a pre-charge voltage Vpg is applied. In the above-described structure, as described later, the photosensing function is realized by applying a predetermined voltage from the top gate driver 111 to the top gate terminals TG, while the readout function is realized by applying a predetermined voltage from the bottom gate driver 112 to the bottom gate terminals BG, then sending the output voltage of the photosensors

10 to the output circuit section 113 via the data lines 103, and outputting serial data Vout.

FIGS. 33A to 33D are timing charts showing a method of controlling the photosensor system, and showing a detecting period (i-th row processing cycle) in the i-th row of the sensor array 100. First, a high-level pulse voltage (reset pulse; e.g., Vtg = +15V) ϕTi shown in FIG. 33A is applied to the top gate line 101 of the i-th row, and during a reset period T_{reset}, reset operation for discharging the double-gate photosensors 10 of the i-th row is executed.

Subsequently, a bias voltage ϕTi of low level (e.g., Vtg = -15V) is applied to the top gate line 101 of the i-th row, thereby finishing the reset period T_{reset} and starting a charge accumulating period Ta in which the channel region is charged. During the charge accumulating period Ta, charges (positive holes) corresponding to the amount of light entering each sensor from the top gate electrode side are accumulated in the channel region.

Then, a pre-charge pulse ϕpg shown in FIG. 33C with a pre-charge voltage Vpg is applied to the data lines 103 during the charge accumulating period Ta, and after a pre-charge period T_{prch} for making the drain electrodes 13 keep a charge, a bias voltage (readout pulse ϕBi) of high level (e.g., Vbg = +10V) shown in FIG. 33B is applied to the bottom gate line 102 of the

i-th row. At this time, the double-gate photosensors 10 of the i-th row are turned on to start a readout period T_{read}.

During the readout period T_{read}, the charges accumulated in the channel region serve to moderate a low-level voltage (e.g., Vtg = -15V) which has an opposite polarity of charges accumulated in the channel region and is applied to each top gate terminal TG. Therefore, an n-type channel is formed by the voltage Vbg at each bottom gate terminal BG, the voltage VD at the data lines 103 gradually reduces in accordance with the drain current with lapse of time after the pre-charge voltage Vpg is applied. More specifically, the tendency of change in the voltage VD at the data lines 103 depends upon the charges accumulating period Ta and the amount of received light. As shown in FIG. 33D, the voltage VD tends to gradually reduce when the incident light is dark, i.e., a small amount of light is received, and hence only small charges are accumulated, whereas the tend to suddenly reduce when the incident light is bright, i.e., a large amount of light is received, and hence large charges are accumulated. From this, it is understood that the amount of radiation can be calculated by detecting the voltage VD at the data lines 103 a predetermined period after the start of the readout period T_{read}, or by detecting a period required until the voltage VD

reaches a predetermined threshold voltage.

Image reading is performed by sequentially executing the above-described drive-control for each line of the sensor array 100, by executing the control for each line in a parallel manner at different timings at which the driving pulses do not overlap.

Although the case of using the double-gate photosensor as a photosensor has been described above, even a photosensor system using a photodiode or phototransistor as a photosensor has operation steps: reset operation → charge accumulating operation → pre-charge operation → reading operation, and uses a similar drive sequence. The conventional photosensor system as above has the following problems.

(1) To read a subject image in various use environments in a photosensor system using the above-described photosensor, the reading sensitivity (charge accumulating period) must be properly set. The proper charge accumulating period changes depending on changes in ambient conditions such as the illuminance of external light in a use environment, and also changes when the characteristics of the photosensor change. In the prior art, therefore, a circuit for detecting the illuminance of external light must be additionally arranged. Alternatively, reading operation (to be referred to as pre-reading operation hereinafter) of changing the charge accumulating periods to a plurality

of stages before the start of normal reading operation of a subject image must be executed to obtain the optimal value of the charge accumulating period from the read result. However, a reading sensitivity setting method of uniquely and automatically setting a proper charge accumulating period based on a read result every charge accumulating period that is obtained by pre-reading operation has not been developed yet.

(2) If a foreign substance attaches to the sensing surface of a photosensor or a defect is generated in a photosensor element in setting the reading sensitivity based on the result of pre-reading operation, and a read result obtained every charge accumulating period by pre-reading operation is directly used, an abnormal value is contained in the read result to fail in setting a proper charge accumulating period and inhibiting accurate reading operation of a subject image. For example, when this photosensor system is applied to a fingerprint reading apparatus, the apparatus may malfunction in fingerprint recognition processing.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to provide a reading sensitivity setting method of uniquely and automatically setting a proper reading sensitivity on the basis of read results obtained

immediately before the start of normal reading operation of a subject image in order to accurately read a subject image in various use environments in a photosensor system having a photosensor array constituted by two-dimensionally arraying a plurality of photosensors. It is another object of the present invention to prevent any malfunction in setting the reading sensitivity even if a foreign substance attaches to the sensing surface of a photosensor, or a photosensor element becomes defective.

To achieve the above objects, a photosensor system according to the present invention comprises a photosensor array constituted by two-dimensionally arraying photosensors, a driver circuit for supplying a drive signal to the photosensors, a controller for controlling reading operation of a subject image and sensitivity setting, and a RAM for storing read image data, data relating to sensitivity setting processing, and the like.

To achieve the above objects, according to the first reading sensitivity setting method of the present invention, pre-reading operation of changing the charge accumulating period at a plurality of stages for, e.g., respective rows is executed before the start of normal reading operation of a subject image. A row in which the dynamic range of lightness data for each row is maximum, or a row in which the displacement

(differentiated value) of lightness data between rows in a specific column direction is maximum is extracted from read image data. An image reading sensitivity set for the extracted row is set as an optimal sensitivity. This can reduce the data amount to be processed, simplify sensitivity setting processing, and shorten the required time. Even when the ambient light or the characteristics of the photosensor change, an optimal image reading sensitivity can be set in accordance with the changes.

To achieve the above objects, according to the second reading sensitivity setting method of the present invention, pre-reading operation of changing the charge accumulating period at a plurality of stages for, e.g., respective rows is executed before the start of normal reading operation of a subject image. A row in which the dynamic range is maximum and the linearly differentiated value of the dynamic range is minimum is extracted from the dynamic ranges of lightness data of read image data for respective rows, or the dynamic ranges of lightness data for respective rows from which high-frequency components upon changes in the dynamic ranges of the rows are removed. An image reading sensitivity set for the extracted row is set as an optimal sensitivity. A row corresponding to an appropriate image reading sensitivity can be extracted without any influence of an abnormal pixel generated

by a foreign substance attached to the sensing surface of the photosensor array, a defect of the photosensor element, or the like. The present invention can provide a reliable reading sensitivity setting method.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a block diagram showing an arrangement of a photosensor system according to the present invention;

FIG. 2 is a block diagram showing an arrangement of a controller applied to the first embodiment;

FIG. 3 is a flow chart showing the operation of the first embodiment;

FIG. 4 is a view showing an example of image data

when a fingerprint image is read by pre-reading operation in the first embodiment;

FIGS. 5A to 5E are graphs each showing changes in lightness data in a specific row that are obtained by pre-reading operation in the first embodiment;

FIGS. 6A and 6B are views showing the relationship between a table representing the dynamic range of lightness data of each row that is obtained by pre-reading operation in the first embodiment, and a corresponding row number vs. image reading sensitivity correspondence table;

FIG. 7 is a view showing another example of image data when a fingerprint image is read by pre-reading operation in a modification of the first embodiment;

FIGS. 8A to 8E are graphs each showing changes in lightness data in the column range of a specific region in a specific row that are obtained by pre-reading operation in the modification of the first embodiment;

FIGS. 9A and 9B are tables showing the relationship between a table representing the dynamic range of lightness data of each row that is obtained by pre-reading operation in the modification of the first embodiment, and a corresponding row number vs. image reading sensitivity correspondence table;

FIG. 10 is a flow chart showing the operation of the second embodiment;

FIG. 11 is a view showing an example of image data

when a fingerprint image is read by pre-reading operation in the second embodiment;

FIGS. 12A and 12B are graphs, respectively, showing the value of lightness data in a predetermined column that is obtained by pre-reading operation in the second embodiment, and the differentiated value of lightness data between rows;

FIGS. 13A and 13B are views showing the relationship between a table representing the differentiated value of lightness data between rows in a predetermined column that is obtained by pre-reading operation in the second embodiment, and a corresponding row number vs. image reading sensitivity correspondence table;

FIG. 14 is a flow chart showing the operation of the third embodiment;

FIG. 15 is a view showing examples of image data and a sensitivity determination range when a fingerprint image is read by pre-reading operation in the third embodiment;

FIG. 16 is a graph showing changes in lightness data of a specific row in the sensitivity determination range of image data read by pre-reading operation in the third embodiment;

FIGS. 17A and 17B are graphs showing the relationship between changes in the dynamic ranges of respective rows of image data read by pre-reading operation in the third embodiment, and changes in the

linearly differentiated values of the dynamic ranges of respective rows;

FIGS. 18A and 18B are views showing the relationship between a table representing the dynamic range of each row and the linearly differentiated value of the dynamic range that are obtained by pre-reading operation in the third embodiment, and a corresponding row number vs. image reading sensitivity correspondence table;

FIGS. 19A and 19B are views showing the relationship between a table representing the dynamic range of each row and a corresponding row number vs. image reading sensitivity correspondence table when the first embodiment is applied to image data read by pre-reading operation in the third embodiment;

FIG. 20 is a view showing a case wherein an abnormal value exists in read image data of a fingerprint image in pre-reading operation in the third embodiment;

FIG. 21 is a graph showing changes in the dynamic ranges of respective rows when an abnormal value exists in read image data of a fingerprint image in pre-reading operation in the third embodiment;

FIGS. 22A and 22B are graphs showing the relationship between changes in the dynamic ranges of respective rows, and changes in the linearly differentiated values of the dynamic ranges of

respective rows when an abnormal value exists in read image data of a fingerprint image in pre-reading operation in the third embodiment;

FIG. 23 is a flow chart showing the operation of the fourth embodiment;

FIG. 24 is a block diagram showing an arrangement of a controller applied to the fifth embodiment;

FIG. 25 is a flow chart showing the operation of the fifth embodiment;

FIG. 26 is a view showing a case wherein an abnormal value across a plurality of rows exists in read image data of a fingerprint image in pre-reading operation of the fifth embodiment;

FIG. 27A is a graph showing changes in the dynamic ranges of respective rows when an abnormal value across a plurality of rows exists in read image data of a fingerprint image in pre-reading operation of the fifth embodiment, and the dynamic range discretely varies for respective rows;

FIG. 27B is a graph showing the dynamic range distribution of lightness data of respective rows after abnormal value removing operation in the fifth embodiment;

FIGS. 28A to 28J are timing charts showing the first embodiment of an image reading sensitivity setting method applied to pre-reading operation in each embodiment;

FIGS. 29A to 29J are timing charts showing the second embodiment of an image reading sensitivity setting method applied to pre-reading operation in each embodiment;

FIGS. 30A to 30H are timing charts showing an embodiment when an effective voltage adjusting period is set after pre-reading and image reading periods in a photosensor system drive control method according to the present invention;

FIG. 31A is a sectional view showing the structure of a conventional double-gate photosensor;

FIG. 31B is an equivalent circuit diagram showing the double-gate photosensor;

FIG. 32 is a schematic view showing a photosensor system constituted by two-dimensionally arraying double-gate photosensors; and

FIGS. 33A to 33D are timing charts showing a conventional drive method for the double-gate photosensor system.

DETAILED DESCRIPTION OF THE INVENTION

Methods of controlling a photosensor system according to the present invention will be described in detail with reference to the several views of the accompanying drawings. Although in embodiments described below, a double-gate photosensor is applied as a photosensor, the present invention is not limited to the double-gate photosensor, but is also applicable

to a photosensor system using another type of photosensor.

FIG. 1 is a block diagram showing an arrangement of a photosensor system according to the present invention. The double-gate photosensor shown in FIG. 31A is used, and the arrangement of the photosensor system shown in FIG. 32 will be referred to if necessary. The same reference numerals as in the photosensor system shown in FIG. 32 denote the same parts.

As is shown in FIG. 1, the photosensor system according to an embodiment comprises a photosensor array 100 including double-gate photosensors 10 shown in FIG. 31A that are arrayed two-dimensionally, a top gate driver 111 for applying a predetermined reset pulse to a top gate terminal TG of each double-gate photosensor 10 at a predetermined timing, a bottom gate driver 112 for applying a predetermined readout pulse to a bottom gate terminal BG of each double-gate photosensor 10 at a predetermined timing, an output circuit section 113 constituted by an amplifier 116, and a column switch 114 and pre-charge switch 115 for reading a data line voltage and applying a pre-charge voltage to each double-gate photosensor 10, respectively, an analog/digital converter (to be referred to as an A/D converter hereinafter) 117 for converting the read data voltage as an analog signal into image data

as a digital signal, a controller 120 which is adopted to control the operation of reading a subject image by the photosensor array 100, and to exchange data with an external function section 200, and which controls sensitivity setting in the present invention, and a RAM 130 that stores, for example, read image data, data relating to setting of a reading sensitivity described later.

The structure including the photosensor array 100, top gate driver 111, bottom gate driver 112, and output circuit section 113 is the same as and has the same function as the photosensor system shown in FIG. 32. In addition to this structure, this embodiment adopts the A/D converter 117, controller 120, and RAM 130 to enable various types of control as described below.

The controller 120 outputs control signals ϕtg and ϕbg to the top and bottom gate drivers 111 and 112, respectively, which, in turn, output predetermined voltages (reset pulse and readout pulse) to the top gate terminal TG and bottom gate terminal BG of each double-gate photosensor 10 of the photosensor array 100, respectively. The controller 120 also outputs a control signal ϕpg to the pre-charge switch 115 to control execution of the operation of reading a subject image. A data line voltage read from the photosensor array 100 via the column switch 114 and amplifier 116 is converted into a digital signal by the A/D converter

117, and supplied as image data. The controller 120 also has a function of executing predetermined image processing for image data, writing or reading image data into or from the RAM 130. The controller 120 serves as an interface with the external function section 200 that executes predetermined processing such as image data identification, modification, and the like.

The controller 120 has another function of controlling control signals to be output to the top and bottom gate drivers 111 and 112 to set an optimal reading sensitivity for reading a subject image in accordance with ambient environments such as the illuminance of external light, i.e., an optimal charge accumulating period for each double-gate photosensor 10.

As will be described below, photosensor system drive control methods according to embodiments of the present invention are based on the arrangement of this photosensor system.

<First Embodiment>

The first embodiment of the photosensor system drive control method according to the present invention will be described with reference to the several views of the accompanying drawing.

FIG. 2 is a block diagram showing an arrangement of a controller 120 applied to the first embodiment.

As shown in FIG. 2, the controller 120 comprises a device controller 121 for controlling a top gate driver 111, bottom gate driver 112, and output circuit section 113, a data controller 122 for managing various data such as image data, write data, and readout data to the RAM 130, and a main controller 123 which supervises the controllers 121 and 122 and interfaces with an external function section.

The controller 120 further comprises a data comparator 124 for comparing the sizes of specific measurement data based on image data input as a digital signal from a photosensor array 100 via an A/D converter 117 to extract maximum and minimum values, an adder 125 having a function of calculating, e.g., the difference between measurement data, a data selector 126 for receiving processed image data via the A/D converter 117, data comparator 124, and adder 125, and switching write/readout in/from the RAM, re-input to the data comparator 124 and adder 125, and output to the external function section via the data controller 122 in accordance with the received data, and a sensitivity setting register 127 for changing control signals to be output from the device controller 121 to the top and bottom gate drivers 111 and 112 so as to optimize the reading sensitivity of the photosensor array on the basis of a control signal from the data controller 122.

The operation of the first embodiment in the operation control method of the photosensor system using the above controller will be explained with reference to FIG. 3. FIG. 3 is a flow chart showing an operation up to read of a subject image with an optimal sensitivity according to the first embodiment in operation control of the photosensor system. This operation will be described by properly referring to the arrangement of the photosensor system shown in FIGS. 1 and 2.

In S11 (pre-reading step) of FIG. 3, the main controller 123 controls to set an image reading sensitivity for pre-reading operation in the sensitivity setting register 127 via the data controller 122, and pre-reads a subject image prior to normal reading operation of a subject image. Similar to normal image reading operation, pre-reading operation is done by executing a series of processes: reset operation → charge accumulating operation → pre-charge operation → readout operation. In pre-reading operation, the image reading sensitivity is changed stepwise for, e.g., respective rows of a subject image so as to read one subject image at a plurality of different sensitivities. The image reading sensitivities of respective rows are stored in the RAM 130 in, e.g., a table format (row number vs. image reading sensitivity correspondence table) in correspondence

with row numbers. A detailed image reading sensitivity setting method will be described later.

In S12 (image data conversion step) of FIG. 3, the image data read by pre-reading operation is converted into a digital signal via the amplifier 116 and A/D converter 117, and input as lightness data corresponding to the bright/dark pattern of the subject image to the data comparator 124. In this case, the lightness data is expressed by, e.g., 256 gray levels.

In S13 (step of extracting the maximum and minimum values of each row) of FIG. 3, the data comparator 124 extracts the maximum and minimum values of each row from the lightness data input to the data comparator 124, and outputs them to the adder 125. That is, the data comparator 124 extracts lightness data representing a maximum value (gray level value of the brightest pixel) contained in each row, and lightness data representing a minimum value (gray level value of the darkest pixel).

In S14 (step of calculating the dynamic range of each row) of FIG. 3, the adder 125 calculates as a dynamic range the difference between the maximum and minimum values of lightness data of each row, and stores the dynamic range in the RAM 130 via the data selector 126. The adder 125 executes dynamic range calculation processing for all the rows.

In S15 (step of extracting a row number having

a maximum dynamic range) of FIG. 3, the dynamic ranges of respective rows stored in the RAM 130 are read out via the data selector 126, and input to the data comparator 124, which extracts a row number having the maximum dynamic range among the dynamic ranges of the respective rows.

In S16 (sensitivity referring/extraction step) of FIG. 3, the row number vs. image reading sensitivity correspondence table stored in the RAM 130 is looked up based on the row number having the maximum dynamic range, and an image reading sensitivity, i.e., charge accumulating period set for this row is extracted.

In S17 (extracted sensitivity setting step) of FIG. 3, the data controller 122 rewrites the sensitivity setting register 127 to set the image reading sensitivity in the sensitivity setting register 127 to the extracted image reading sensitivity.

In S18 (subject image reading step) of FIG. 3, normal reading operation of a subject image is executed at the extracted image reading sensitivity set in the sensitivity setting register 127.

An example of applying the first embodiment of the photosensor system drive control method using the above-described controller to a fingerprint reading apparatus will be described with reference to FIGS. 4 to 6B.

FIG. 4 is a view showing an example of fingerprint

image data when a subject (fingerprint) image is read while the image reading sensitivity is changed stepwise for respective rows in pre-reading operation. FIGS. 5A to 5E are graphs each showing changes in lightness data in a specific row that are obtained by pre-reading operation. FIGS. 6A and 6B are views for illustrating tables showing the relationship between the dynamic range of lightness data of each row that is obtained by pre-reading operation, and a row number vs. image reading sensitivity correspondence table. Assume that image data is read out in units of matrices of 256 rows × 196 columns. A larger lightness data value represents a brighter image, and a smaller lightness data value represents a darker image. In pre-reading operation, the image reading sensitivity is set higher (charge accumulating period is set longer) for a larger row number (upward in FIG. 4), and lower (charge accumulating period is set shorter) for a smaller row number (downward in FIG. 4). In FIG. 4, as the row number increases (upward in FIG. 4), the ridge/valley pattern of the fingerprint becomes weaker under the influence of external light, and at last is read as an almost invisibly bright image. On the other hand, as the row number decreases (downward in FIG. 4), the ridge/valley pattern of the fingerprint becomes darker, and at last is read as an almost invisibly dark image. The lightness data level is expressed by 256 gray

levels, and its lower and upper limit values are set to 0 and 255, respectively.

In this image data, changes in lightness data in the 176th, 152nd, 128th, 104th, and 80th rows are extracted, and plotted as shown in FIGS. 5A to 5E. In the 176th row, as shown in FIG. 5A, the sensitivity is set high, so that lightness data substantially converges to the upper limit value and hardly provides any information as image data. In the 152nd row, as shown in FIG. 5B, the sensitivity is set relatively high, lightness data reaches the upper limit value in some columns, and all the ridge/valley (bright/dark) patterns of image data cannot be read. To the contrary, in the 128th row, as shown in FIG. 5C, lightness data does not reach either the upper or lower limit value on all the columns, and is distributed between the upper and lower limit values. In the 104th row, as shown in FIG. 5D, the sensitivity is set relatively low, and most of lightness data is distributed between the upper and lower limit values. However, lightness data reaches the lower limit value on some columns, and all the ridge/valley patterns of image data cannot be read. In the 80th row, as shown in FIG. 5E, the sensitivity is set low, so that lightness data substantially converges to the lower limit value and hardly provides any information as image data.

Maximum and minimum values are extracted as numerical data on the basis of changes in the lightness data distribution of each of the respective rows shown in FIGS. 5A to 5E, and the dynamic range is calculated as the difference and listed on a table as shown in FIG. 6A. In the 176th and 152nd rows, lightness data reaches the upper limit. Since the maximum value is fixed to 255, the dynamic range depends on the minimum value. In the 104th and 80th rows, lightness data reaches the lower limit. Since the minimum value is fixed to 0, the dynamic range depends on the maximum value. In contrast, in the 128th row, lightness data does not reach either the upper or lower limit, and thus the dynamic range depends on the difference between the maximum and minimum values of the lightness data. The 128th row can attain the largest dynamic range, compared to the 176th, 152nd, 104th, and 80th rows. In other words, it can be determined that lightness data in the 128th row is image data having a fine contrast corresponding to the ridge/valley pattern of a fingerprint, and an optimal image reading sensitivity is set.

The RAM 130 stores the row number vs. image reading sensitivity correspondence table shown in FIG. 6B, and stores image reading sensitivities, i.e., charge accumulating periods T_1 to T_{256} for respective row numbers.

The row number vs. image reading sensitivity correspondence table is looked up for the 128th row having the maximum dynamic range, thereby obtaining an image reading sensitivity, i.e., charge accumulating period T_{128} set for the 128th row.

If a subject (fingerprint) image is read using the obtained charge accumulating period T_{128}, the image can be satisfactorily read.

The first embodiment has exemplified only the 176th, 152nd, 128th, 104th, and 80th rows as rows subjected to extraction and calculation processes of the dynamic range of lightness data. As a matter of course, the same processes can be executed for all 256 rows. When extraction and calculation processes of the dynamic range of lightness data are performed not for all the rows but for only selected specific rows, like this embodiment, the number of data to be processed can be decreased to simplify processing and shorten the time required for sensitivity setting processing, and the operation can quickly shift to normal reading operation of a subject image.

A modification of the first embodiment will be described with reference to FIGS. 7, 8A to 8E, 9A, and 9B. FIG. 7 is a view showing another example of fingerprint image data when a subject (fingerprint) image is read while the image reading sensitivity is changed stepwise for respective rows in pre-reading

operation. FIGS. 8A to 8E are graphs each showing changes in lightness data in the column range of a specific region in a specific row that are obtained by pre-reading operation. FIGS. 9A and 9B are tables showing the relationship between the dynamic range of lightness data of each row that is obtained by pre-reading operation, and a row number vs. image reading sensitivity correspondence table. In this modification, unlike the first embodiment, lightness data of each row used to extract maximum and minimum values is limited to the column range of a specific region, and maximum and minimum values in this column range are extracted.

More specifically, in reading the ridge/valley pattern of a fingerprint as a subject image, the peripheral portion of a finger (region representing the edge of a finger in FIG. 7) touches an image reading surface weaker than the center of the finger. In addition, the ridge/valley pattern of the peripheral portion is not clear, and is influenced by external factors such as external light incident via the semitransparent layer of a skin surface layer. This degrades the uniformity and relevance of image data. To prevent this, the modification processes lightness data limited to a column range around the center of a finger which is relatively hardly influenced by external factors and has a clear ridge/valley pattern,

thereby achieving appropriate extraction processing of maximum and minimum values.

As shown in FIG. 7, the reading sensitivity of a subject image is set higher (charge accumulating period is set longer) for a larger row number. For example, changes in lightness data in a predetermined column range (85th column to 112th column) in the 176th, 152nd, 128th, 104th, and 80th rows are extracted and plotted as shown in FIGS. 8A to 8E. Similar to FIGS. 5A to 5E described above, only in the 128t row, lightness data does not reach either the upper or lower limit value in the entire column range partially limited, and is distributed between the upper and lower limit values. In the remaining rows, lightness data reaches the upper or lower limit value, and all the ridge/valley patterns of image data cannot be read.

FIG. 9A shows the results of extracting maximum and minimum values as numerical data on the basis of changes in lightness data distribution of each row, and calculating the dynamic range from the difference. It can be determined that the dynamic range of lightness data in the 128th row is maximum, and that image data having a fine contrast corresponding to the ridge/valley pattern of a fingerprint is obtained. That is, an optimal image reading sensitivity can be determined to be set.

As shown in FIG. 6B, the row number vs. image

reading sensitivity correspondence table stored in the RAM 130 stores charge accumulating periods T_1 to T_{256} for respective row numbers. As shown in FIG. 9B, the row number vs. image reading sensitivity correspondence table is looked up for the 128th row having the maximum dynamic range, thereby attaining an image reading sensitivity set for the 128th row, i.e., charge accumulating period T_{128} of the double-gate photosensor.

The sensitivity setting method of this modification can determine a row in an optimal image reading state on the basis of the dynamic range of lightness data in a predetermined column range for each row in setting an optimal image reading sensitivity based on the results of pre-reading operation. Accordingly, the data amount to be processed can be decreased to simplify sensitivity setting processing and shorten the required time.

<Second Embodiment>

The second embodiment of a photosensor system drive control method to which the same controller as in the first embodiment can be applied will be described with reference to the several views of the accompanying drawing.

FIG. 10 is a flow chart showing an operation up to read of a subject image with an optimal sensitivity according to the second embodiment in operation control

of the photosensor system. This operation will be described by properly referring to the arrangement of the photosensor system shown in FIGS. 1 and 2.

In S21 (pre-reading step) of FIG. 10, prior to normal reading operation of a subject image, a main controller 123 controls to set an image reading sensitivity for pre-reading operation in a sensitivity setting register 127 via a data controller 122, and executes pre-reading operation of reading a subject image at a plurality of different sensitivities while changing the image reading sensitivity stepwise for respective rows of the subject image. The image reading sensitivities of respective rows are stored as a row number vs. image reading sensitivity correspondence table in a RAM 130 in correspondence with row numbers. This pre-reading operation is the same as the operation in the first embodiment, and a detailed method of setting the image reading sensitivity (charge accumulating period) will be described below.

In S22 (image data conversion step) of FIG. 10, the image data read by pre-reading operation is converted into a digital signal via an amplifier 116 and A/D converter 117, and input as lightness data corresponding to the bright/dark pattern of the subject image to a data comparator 124. In this case, the lightness data is expressed by, e.g., 256 gray levels.

In S23 (data extraction step in the column

direction) of FIG. 10, the data comparator 124 extracts lightness data on a selected column, and outputs it to an adder 125.

In S24 (differentiation processing step in the column direction) of FIG. 10, the adder 125 calculates the displacement (differentiated value) of each row in the column direction of the extracted luminance data, and stores the displacement in the RAM 130.

In S25 (step of extracting a row number having the maximum differentiated value) of FIG. 10, the differentiated values of lightness data stored in the RAM 130 are read out via the data selector 126, and input to the data comparator 124, which extracts a row number having the maximum differentiated value among the differentiated values of lightness data.

In S26 (sensitivity referring/extraction step) of FIG. 10, the row number vs. image reading sensitivity correspondence table stored in the RAM 130 is referred based on the row number having the maximum differentiated value, and an image reading sensitivity, i.e., charge accumulating period set for this row is extracted.

In S27 (extracted sensitivity setting step) of FIG. 10, the data controller 122 rewrites the sensitivity setting register 127 to set the image reading sensitivity in the sensitivity setting register 127 to the extracted image reading sensitivity. In S28

(subject image reading step) of FIG. 10, normal reading operation of a subject image is executed at the extracted image reading sensitivity set in the sensitivity setting register 127.

An example of applying the second embodiment of the photosensor system drive control method to a fingerprint reading apparatus will be described with reference to FIGS. 11 to 13B.

FIG. 11 is a view showing an example of fingerprint image data when a subject (fingerprint) image is read while the image reading sensitivity is changed stepwise for respective rows in pre-reading operation. FIGS. 12A and 12B are graphs, respectively, showing the value of lightness data in a predetermined column that is obtained by pre-reading operation, and the displacement (differentiated value) of lightness data between rows. FIGS. 13A and 13B are tables showing the relationship between the displacement of lightness data between rows in a predetermined column that is obtained by pre-reading operation, and a row number vs. image reading sensitivity correspondence table. Assume that image data is read out in units of matrices of 256 rows × 196 columns. A larger lightness data value represents a brighter image, and a smaller lightness data value represents a darker image.

In pre-reading operation, the image reading sensitivity is set higher (charge accumulating period

is set longer) for a larger row number (upward in FIG. 11), and lower (charge accumulating period is set shorter) for a smaller row number (downward in FIG. 11). For example, lightness data of respective rows (1st to 256th rows) on the 98th column are extracted and plotted as shown in FIG. 12A.

In a region having a small row number, the image reading sensitivity is set low, and lightness data converges to the lower limit value. In a region having a large row number, the image reading sensitivity is set high, and lightness data converges to the upper limit value. To the contrary, in a region around the central row (128th row), lightness data does not reach either the upper or lower limit value, and is distributed between the upper and lower limit values. Further, lightness data tends to change from the lower limit value to the upper limit value.

Differentiated values representing the displacements of lightness data of respective rows are calculated based on changes in lightness data of these rows, and plotted to obtain a distribution as shown in FIG. 12B. The distribution of the differentiated value of lightness data shown in FIG. 12B is listed on a table as shown in FIG. 13A. From this table, the differentiated value is observed to maximize between the 125th and 126th rows, and image data having a fine contrast corresponding to the ridge/valley pattern of

the fingerprint is determined to be obtained. That is, an optimal image reading sensitivity can be determined to be set.

Similar to the table shown in FIG. 6B, the row number vs. image reading sensitivity correspondence table stored in the RAM 130 stores charge accumulating periods T_1 to T_{256} for respective row numbers. This table is looked up for the 125th and 126th rows having the maximum differentiated value to acquire image reading sensitivities set for the 125th and 126th rows, i.e., charge accumulating periods T_{125} and T_{126} of the photosensor. The sensitivity setting register is rewritten to set a set value determined based on the two charge accumulating periods T_{125} and T_{126}, i.e., the average of the charge accumulating periods T_{125} and T_{126}. A subject (fingerprint) image is read at this optimal image reading sensitivity.

Similar to the modification of the first embodiment, the column number of lightness data to be processed is desirably specified to a column around the central portion of a subject (finger) which is relatively hardly influenced by external factors and at which the bright/dark pattern (ridge/valley pattern) of a subject image can be read clearly.

In setting an optimal image reading sensitivity based on the results of pre-reading operation, the sensitivity setting method of the second embodiment can

easily determine a row in an optimal image reading state on the basis of the displacement of lightness data of each row in a specific column, and can set an image reading sensitivity (charge accumulating period) set for this row as an optimal sensitivity. Lightness data to be processed suffices to be one column (i.e., several rows), and data to be processed in sensitivity setting processing can be greatly decreased to further simplify sensitivity setting processing and shorten the required time.

<Third Embodiment>

The third embodiment of a photosensor system drive control method according to the present invention will be described with reference to the several views of the accompanying drawings.

The arrangement of a controller applied to the third embodiment has the same arrangement block as that in the first and second embodiments shown in FIG. 2. In addition, an adder 125 calculates a dynamic range from the difference between the maximum and minimum values of measurement data, and calculates the difference between respective dynamic ranges, i.e., linearly differentiated value. A data comparator 124 has a function of extracting the maximum value of a dynamic range calculated by the adder 125, and the minimum or maximum value of the difference (linearly differentiated value) between dynamic ranges.

FIG. 14 is a flow chart showing an operation up to read of a subject image with an optimal sensitivity according to the third embodiment in the photosensor system operation control method using the above controller. This operation will be described by properly referring to the arrangement of the photosensor system shown in FIGS. 1 and 2.

In S31 (pre-reading step) of FIG. 14, prior to normal reading operation of a subject image, a main controller 123 controls to set an image reading sensitivity for pre-reading operation in a sensitivity setting register 127 via a data controller 122, and executes pre-reading operation of reading a subject image at a plurality of different sensitivities while changing the image reading sensitivity stepwise for respective rows of the subject image. The image reading sensitivities of respective rows are stored as a row number vs. image reading sensitivity correspondence table in a RAM 130 in correspondence with row numbers. This pre-reading operation is the same as the operation in the first embodiment, and a detailed method of setting the image reading sensitivity (charge accumulating period) will be described below.

In S32 (image data conversion step) of FIG. 14, the image data read by pre-reading operation is converted into a digital signal via an amplifier 116

and A/D converter 117, and input as lightness data corresponding to the bright/dark pattern of the subject image to a data comparator 124. In this case, the lightness data is expressed by, e.g., 256 gray levels.

In S33 (step of extracting the maximum and minimum values of each row) of FIG. 14, the data comparator 124 extracts the maximum and minimum values of lightness data of each row, and outputs them to an adder 125. That is, the data comparator 124 extracts lightness data representing a maximum value (gray level value of the brightest pixel) contained in each row, and lightness data representing a minimum value (gray level value of the darkest pixel).

In S34 (step of calculating the dynamic range of each row) of FIG. 14, the adder 125 calculates as a dynamic range the difference between the maximum and minimum values of lightness data of each row, and stores the dynamic range in the RAM 130 via the data selector 126. The adder 125 executes dynamic range calculation processing for all the rows.

In S35 (step of calculating the linearly differentiated value of the dynamic range) of FIG. 14, the dynamic ranges of respective rows stored in the RAM 130 are read out via the data selector 126, and input again to the adder 125, which calculates the difference (linearly differentiated value) between the dynamic ranges of adjacent rows. The results are stored in the

RAM 130 via the data selector 126.

In S36 (step of extracting a row number having a maximum dynamic range and minimum linearly differentiated value) of FIG. 14, data of the dynamic ranges of respective rows and data of the linearly differentiated values of the dynamic ranges which are stored in the RAM 130 are read out via the data selector 126, and input to the data comparator 124, which extracts a row number at which the dynamic range maximizes and the linearly differentiated value of the dynamic range minimizes (to 0 or a value close to 0).

In S37 (sensitivity referring/extraction step) of FIG. 14, the row number vs. image reading sensitivity correspondence table stored in the RAM 130 is looked up based on the extracted row number, and an image reading sensitivity, i.e., charge accumulating period set for this row is extracted.

In S38 (extracted sensitivity setting step) of FIG. 14, the data controller 122 rewrites the sensitivity setting register 127 to set the image reading sensitivity in the sensitivity setting register 127 to the extracted image reading sensitivity. In S39 (subject image reading step) of FIG. 14, normal reading operation of a subject image is executed at the extracted image reading sensitivity set in the sensitivity setting register 127.

An example of applying the third embodiment of

the photosensor system drive control method to a fingerprint reading apparatus will be described with reference to FIGS. 15 to 18B.

FIG. 15 is a view showing an example of image data when a subject (fingerprint) image is read while the image reading sensitivity is changed stepwise for respective rows in pre-reading operation. FIG. 16 is a graph showing changes in lightness data of respective pixels of a specific row in the column direction that are obtained by pre-reading operation. FIGS. 17A and 17B are graphs showing the relationship between changes in the dynamic ranges of respective rows and changes in the linearly differentiated values of the dynamic ranges of respective rows. FIGS. 18A and 18B are views for illustrating tables showing the relationship between the dynamic range of each row and the linearly differentiated value of the dynamic range that are obtained by pre-reading operation, and a row number vs. image reading sensitivity correspondence table. Assume that image data is read out in units of matrices of 256 rows $\times$ 196 columns. A larger lightness data value represents a brighter image, and a smaller lightness data value represents a darker image.

In pre-reading operation, the image reading sensitivity is set higher (charge accumulating period is set longer) for a larger row number (upward in FIG. 15), and lower (charge accumulating period is

set shorter) for a smaller row number (downward in FIG. 15). In FIG. 15, as the row number increases (upward in FIG. 15), the ridge/valley pattern of the fingerprint becomes weaker under the influence of external light, and at last is read as an almost invisibly bright image. On the other hand, as the row number decreases (downward in FIG. 15), the ridge/valley pattern of the fingerprint becomes darker, and at last is read as an almost invisibly dark image. The lightness data level is expressed by 256 gray levels, and its lower and upper limit values are set to 0 and 255, respectively.

In this image data, a sensitivity determination range used to extract a row having an optimal sensitivity is preferably limited to a region having a fine contrast corresponding to the ridge/valley pattern of the fingerprint. This embodiment will exemplify sensitivity setting processing when a row/column range defined by 64th to 191st rows and 67th to 130th columns is set as the sensitivity determination range.

In the sensitivity determination range shown in FIG. 15, for example, changes in lightness data in the 64th, 96th, 160th, and 191st rows are extracted and plotted as shown in FIG. 16. In the 191st row (represented by the broken line in FIG. 16) and 160th row (represented by the thin line in FIG. 16) within the row range, the sensitivity is set high, and

lightness data converges to a large value (about 220 to 225) and hardly provides any information as image data. In the 96th row (represented by the thick line in FIG. 16), lightness data does not converge to either the upper or lower limit value on all the columns, and exhibits a relatively large vertical displacement corresponding to the bright/dark pattern of image data. In the 64th row (represented by the chain line in FIG. 16), the sensitivity is set low, so that lightness data converges to a small value (about 35) and hardly provides any information as image data.

Maximum and minimum values are extracted from the lightness data distribution of each row, and the difference is calculated to obtain a dynamic range. Obtained dynamic ranges are plotted for row numbers to attain a distribution curve having a maximum value MA in a predetermined row, as shown in FIG. 17A. Further, linear differentiation for the dynamic range distribution, i.e., the slopes of the dynamic range distribution curve for respective rows are calculated, and plotted for row numbers. As shown in FIG. 17B, a linearly differentiated value MB is 0 in a row exhibiting the maximum value MA.

It can be determined that lightness data in the row exhibiting the maximum dynamic range and minimum linearly differentiated value is image data having a fine contrast corresponding to the ridge/valley

pattern of a fingerprint, and an optimal image reading sensitivity is set.

Maximum and minimum values are extracted as numerical data on the basis of changes in the lightness data distribution of each row shown in FIG. 16, and a dynamic range calculated from the difference and a linearly differentiated value calculated from the difference of the dynamic range of each row are listed on a table as shown in FIG. 18A.

In FIG. 18A, when the dynamic range maximizes at R_k in FIG. 18A, and the linearly differentiated value minimizes at D_{k-1} in FIG. 18A, rows L_{k-1} and L_k are extracted as row numbers at which the dynamic range maximizes and the linearly differentiated value minimizes.

As shown in FIG. 6B, the RAM 130 stores a row number vs. image reading sensitivity correspondence table within the sensitivity determination range, and stores image reading sensitivities, i.e., charge accumulating periods T_{64} to T_{191} for respective row numbers.

This row number vs. image reading sensitivity correspondence table is looked up for the extracted rows to extract image reading sensitivities, i.e., charge accumulating periods T_{k-1} and T_k set for the rows L_{k-1} and L_k, which are determined as optimal values. The sensitivity setting register 127 is

rewritten to set, as an optimal image reading sensitivity, a set value determined based on the two extracted charge accumulating periods T_{k-1} and T_k, i.e., the average of the charge accumulating periods T_{k-1} and T_k. A subject (fingerprint) image is read at this optimal image reading sensitivity.

Note that in the distributions of the dynamic range and linearly differentiated value shown in FIGS. 17A and 17B, the linearly differentiated value of a row whose dynamic range has the maximum value MA is 0. In practice, however, a row whose linearly differentiated value is 0 may not exist. Thus, as conditions for extracting a row set to an optimal sensitivity, a row exhibiting the maximum dynamic range and the minimum linearly differentiated value (value nearest to 0) is extracted.

As will be described below, the third embodiment can effectively prevent any malfunction in optimal sensitivity extraction processing even when lightness data contains an abnormal value due to a small foreign substance attached to the fingerprint reading surface of the photosensor, a defect of the photosensor, or the like. This will be explained with reference to FIGS. 19A to 22B.

FIGS. 19A and 19B are tables showing the relationship between the dynamic range distribution of respective rows and a row number vs. image reading

sensitivity correspondence table when the first embodiment is applied as another setting method of setting the optimal sensitivity of the photosensor system. According to this setting method, the optimal value of the image reading sensitivity is determined using a row whose dynamic range has the maximum value MA in the dynamic range distribution (see FIG. 17A) of lightness data in sensitivity setting processing described above.

In this sensitivity setting method, as described above, the dynamic range is calculated based on the lightness data distribution (maximum and minimum values) of each row in FIG. 19A, a row (L_k in FIG. 19A) having the maximum value (e.g., R_k in FIG. 19A) is extracted, and an image reading sensitivity (charge accumulating period T_k) set for the row L_k is extracted and determined as an optimal value.

Operation processing when lightness data contains an abnormal value, and comparison with the third embodiment will be explained.

FIG. 20 is a view showing still another example of image data when a subject (fingerprint) image is read while the image reading sensitivity is changed stepwise for respective rows in pre-reading operation. FIG. 21 is a graph showing changes in the dynamic ranges of respective rows. FIGS. 22A and 22B are graphs showing the relationship between changes in the dynamic ranges

of respective rows, and changes in the linearly differentiated values of the dynamic ranges of respective rows.

As shown in FIG. 20, the sensitivity determination range is set to a row/column range defined by 64th to 191st rows and 67th to 130th columns, similar to FIG. 15, as a region having a fine contrast corresponding to the ridge/valley pattern of a fingerprint in order to extract a row having an optimal sensitivity from image data of the fingerprint. In this case, if an abnormal pixel IL1 exists in a row L within the sensitivity determination range owing to a foreign substance attached to a fingerprint reading surface, a defect of the photosensor, or the like, lightness data of the abnormal pixel IL1 may exhibit an excessive value in comparison with peripheral pixel data. This occurs when, for example, a black point exists on the white background, or a white point exists on the black background. In the distribution of a dynamic range calculated based on the maximum and minimum values of lightness data, the dynamic range of the row L containing the abnormal pixel IL1 appears greatly apart from the change trend of the entire distribution. If the setting method of the first embodiment in which an image reading sensitivity corresponding to a row having the maximum dynamic range is adopted as an optimal value is applied to pre-read image data,

the dynamic range of the row L containing the abnormal pixel IL1 that is irrelevant to an original maximum value MA1 in the change trend of the dynamic range distribution is extracted as a maximum value MA2, and an image reading sensitivity set for the row L having this dynamic range is determined to be an optimal value. In this case, an improper image reading sensitivity (e.g., charge accumulating period longer than an optimal value) is set in the photosensor system. In normal reading operation, accurate reading operation may fail such that a subject image becomes white.

To the contrary, the sensitivity setting method of the third embodiment sets an optimal image reading sensitivity using conditions of extracting a row number at which the dynamic range exhibits the maximum value MA1 and the linearly differentiated value of the dynamic range exhibits a minimum value MB1 within a range where the dynamic range coincides with the entire dynamic range change trend. For this reason, the third embodiment does not extract, as a row corresponding to an optimal reading sensitivity, the row containing the abnormal pixel IL1 in which a dynamic range value MA2 in FIG. 22A deviates from the dynamic range change trend and is a maximum value, but a linearly differentiated value MB2 of the dynamic range in FIG. 22B is not a minimum value.

Hence, even when a subject image contains the abnormal pixel IL1 due to a foreign substance attached to a fingerprint reading surface, a defect of the photosensor, or the like, a row having a fine contrast corresponding to the ridge/valley pattern of a fingerprint can be reliably extracted to determine an optimal charge accumulating period.

According to the sensitivity setting method of the third embodiment, pre-reading operation is executed while the image reading sensitivity is changed stepwise for respective rows. A row in an optimal image reading state is easily and properly determined based on the dynamic range value of each row to lightness data and the linearly differentiated value of the dynamic range. An image reading sensitivity (charge accumulating period) set for the row can be set as an optimal sensitivity. Normal image reading operation of a subject image can be performed at a proper sensitivity without being influenced by an abnormal pixel generated by a foreign substance attached to a fingerprint reading surface, a defect of the photosensor, or the like.

The third embodiment executes sensitivity setting processing in a sensitivity determination range limited to a row/column range defined by 64th to 191st rows and 67th to 130th columns. However, the present invention is not limited to this, and is applicable to the entire

region of image data without limiting the sensitivity determination range.

<Fourth Embodiment>

The fourth embodiment of a photosensor system drive control method according to the present invention to which the same controller as in the third embodiment can be applied will be described with reference to the several views of the accompanying drawing. The fourth embodiment determines whether an abnormal pixel exists in image data by applying the sensitivity setting method of the third embodiment.

FIG. 23 is a flow chart showing an operation up to detection processing of an abnormal pixel according to the fourth embodiment in the photosensor system operation control method using the above-mentioned controller.

In S41 (pre-reading step) of FIG. 23, prior to normal reading operation of a subject image, a main controller 123 controls to set an image reading sensitivity for pre-reading operation in a sensitivity setting register 127 via a data controller 122, and executes pre-reading operation of reading a subject image at a plurality of different sensitivities while changing the image reading sensitivity stepwise for respective rows of the subject image. The image reading sensitivities of respective rows are stored as a row number vs. image reading sensitivity

correspondence table in a RAM 130 in correspondence with row numbers. This pre-reading operation is the same as the operation in the first embodiment, and a detailed method of setting the image reading sensitivity (charge accumulating period) will be described below.

In S42 (image data conversion step) of FIG. 23, the image data read by pre-reading operation is converted into a digital signal via an amplifier 116 and A/D converter 117, and input as lightness data corresponding to the bright/dark pattern of the subject image to a data comparator 124. In this case, the lightness data is expressed by, e.g., 256 gray levels.

In S43 (step of extracting the maximum and minimum values of each row) of FIG. 23, the data comparator 124 extracts the maximum and minimum values of lightness data of each row, and outputs them to an adder 125. That is, the data comparator 124 extracts lightness data representing a maximum value (gray level value of the brightest pixel) contained in each row, and lightness data representing a minimum value (gray level value of the darkest pixel).

In S44 (step of calculating the dynamic range of each row) of FIG. 23, the adder 125 calculates as a dynamic range the difference between the maximum and minimum values of lightness data of each row, and stores the dynamic range in the RAM 130 via the data

selector 126. The adder 125 executes dynamic range calculation processing for all the rows.

In S45 (step of calculating the linearly differentiated value of the dynamic range) of FIG. 23, the dynamic ranges of respective rows stored in the RAM 130 are read out via the data selector 126, and input again to the adder 125, which calculates the difference (linearly differentiated value) between the dynamic ranges of adjacent rows. The results are stored in the RAM 130 via the data selector 126.

In S46 (step of extracting a row number having a maximum dynamic range and maximum linearly differentiated value) of FIG. 23, data of the dynamic ranges of respective rows and data of the linearly differentiated values of the dynamic ranges which are stored in the RAM 130 are read out via the data selector 126, and input to the data comparator 124, which extracts a row number at which the dynamic range maximizes and the linearly differentiated value of the dynamic range maximizes.

In S47 (step of determining presence/absence of an extracted row) of FIG. 23, whether a corresponding row number has been extracted in step S46, i.e., whether a row which satisfies extraction conditions exists is determined. If a corresponding row number is determined based on the determination result to have been extracted, an abnormal pixel is determined to

exist in the image data read by pre-reading operation. If no corresponding row number is determined to have been extracted, no abnormal pixel is determined to exist.

This abnormal pixel detection processing can determine the presence/absence of a foreign substance attached to the read surface for a subject or the subject itself, or the presence/absence of a defect of the sensor element constituting the photosensor array. If an abnormal pixel exists, this can be notified with an alarm or the like to execute proper action, and normal reading operation of a subject image can be appropriately done in S48.

More specifically, as shown in FIG. 20, a predetermined sensitivity determination range is set on image data of a fingerprint. At this time, if the abnormal pixel IL1 exists in the sensitivity determination range due to a foreign substance attached to a fingerprint reading surface, characteristic changes and defects of the photosensor, or the like, lightness data of the abnormal pixel IL1 exhibits an excessive value in comparison with peripheral pixel data. In this case, a dynamic range calculated based on the maximum and minimum values of this lightness data, and its linearly differentiated value appear greatly apart from the remaining normal distribution trend, as shown in FIGS. 21, 22A, and 22B. When the

abnormal detection method of the fourth embodiment is applied to this situation, a row number L at which the dynamic range exhibits the maximum value MA2 and the linearly differentiated value of the dynamic range exhibits the maximum value MB2 is extracted to determine that the abnormal pixel IL1 exists in the image data. As a result, proper action of, e.g., cleaning the sensing surface to remove the foreign substance can be instructed prior to normal reading operation of a subject image.

Note that the abnormal detection method of the fourth embodiment may be executed singly for a predetermined subject image, or may be executed in parallel with the above-described sensitivity setting method.

<Fifth Embodiment>

The fifth embodiment of a photosensor system drive control method according to the present invention will be described with reference to the several views of the accompanying drawing.

The detailed arrangement and operation of a controller applied to the fifth embodiment will be explained with reference to the several views of the accompanying drawing.

FIG. 24 is a block diagram showing an arrangement of the controller applied to this embodiment. As will be described below, this controller has almost the same

arrangement as the controller shown in FIG. 2, and the same reference numerals denote the same parts.

As shown in FIG. 24, a controller 120a in the fifth embodiment comprises a device controller 121 for controlling a top gate driver 111, bottom gate driver 112, and output circuit section 113, a data controller 122 for managing various data such as image data, write data, and readout data to a RAM 130, and a main controller 123 which supervises the controllers 121 and 122 and interfaces with an external function section.

The controller 120a further comprises:

an abnormal value removing section 128 constituted by a Fourier transformation section or circuit 128a for Fourier-transforming specific measurement data based on image data input as a digital signal from a photosensor array 100 via an A/D converter 117, a filtering section or circuit 128b for removing a high-frequency component corresponding to an abnormal value from the Fourier-transformed measurement data, and an inverse Fourier transformation section or circuit 128c for inversely Fourier-transforming the measurement data from which the high-frequency component is removed;

a data comparator 124 for extracting maximum and minimum values by comparing the sizes of measurement data from which abnormal values are removed by the abnormal value removing section 128, and for extracting the maximum value of a dynamic range calculated by

an adder 125 (to be described below) and the minimum value of the difference (linearly differentiated value) between dynamic ranges;

the adder 125 for calculating a dynamic range from the difference between the maximum and minimum values of measurement data, and calculating the difference between dynamic ranges, i.e., linearly differentiated value;

a data selector 126 for receiving measurement data processed via the A/D converter 117, abnormal value removing section 128, data comparator 124, and adder 125, and switching write/readout in/from the RAM 130, re-input to the data comparator 124 and adder 125, and output to the external function section 200 via the data controller 122 in accordance with the received data; and

a sensitivity setting register 127 for changing control signals to be output from the device controller 121 to the top and bottom gate drivers 111 and 112 so as to optimize the reading sensitivity of the photosensor array on the basis of a control signal from the data controller 122.

The operation of the fifth embodiment in the operation control method of the photosensor system using the above controller will be explained with reference to FIG. 25. FIG. 25 is a flow chart showing an operation up to read of a subject image with an

optimal sensitivity according to the fifth embodiment in operation control of the photosensor system. This operation will be described by properly referring to the arrangement of the photosensor system shown in FIGS. 1 and 24.

In S51 (pre-reading step) of FIG. 25, prior to normal reading operation of a subject image, the main controller 123 controls to set an image reading sensitivity for pre-reading operation in the sensitivity setting register 127 via the data controller 122, and executes pre-reading operation of reading a subject image at a plurality of different sensitivities while changing the image reading sensitivity stepwise for respective rows of the subject image. The image reading sensitivities of respective rows are stored as a row number vs. image reading sensitivity correspondence table in the RAM 130 in correspondence with row numbers. This pre-reading operation is the same as the operation in the first embodiment, and a detailed method of setting the image reading sensitivity (charge accumulating period) will be described below.

In S52 (image data conversion step) of FIG. 25, the image data read by pre-reading operation is converted into a digital signal via the amplifier 116 and A/D converter 117, and input as lightness data corresponding to the bright/dark pattern of the subject

image to the abnormal value removing section 128. In this case, the lightness data is expressed by, e.g., 256 gray levels.

In S53 (Fourier transformation step) of FIG. 25, the lightness data input to the abnormal value removing section 128 is Fourier-transformed by the Fourier transformation section 128a on the basis of the dynamic range of lightness data of each row to obtain a frequency distribution representing the variation width of lightness data of each row number.

In S54 (high-frequency component removing step) of FIG. 25, a high-frequency component equal to or higher than a predetermined value is removed from the lightness data frequency distribution converted by the Fourier transformation section 128a. More specifically, a predetermined high-frequency component is removed by passing the data through the filtering section 128b formed from, e.g., a low-pass filter.

In S55 (inverse Fourier transformation step) of FIG. 25, the frequency distribution from which the high-frequency component is removed is inversely Fourier-transformed by the inverse Fourier transformation section 128c to obtain lightness data of each row number again.

A series of abnormal value removing operations of the abnormal value removing section 128 remove from original lightness data a high-frequency component,

i.e., abnormal value which has a steep variation and deviates from the main change trend of lightness data, and extract only the main component of the lightness data in which the dynamic range changes smoothly for each row. The lightness data from which the abnormal value is removed is input to the data comparator 124.

In S56 (step of extracting the maximum and minimum values of each row) of FIG. 25, the data comparator 124 extracts for each row the maximum and minimum values of the lightness data from which the abnormal value is removed, and outputs them to the adder 125. That is, the data comparator 124 extracts lightness data representing a maximum value (gray level value of the brightest pixel) contained in each row, and lightness data representing a minimum value (gray level value of the darkest pixel).

In S57 (step of calculating the dynamic range of each row) of FIG. 25, the adder 125 calculates as a dynamic range the difference between the maximum and minimum values of lightness data of each row, and temporarily stores the dynamic range in the RAM 130 via the data selector 126. The adder 125 executes dynamic range calculation processing for all the rows.

In S58 (step of calculating the linearly differentiated value of the dynamic range) of FIG. 25, the dynamic ranges of respective rows stored in the RAM 130 are read out via the data selector 126, and input

again to the adder 125, which calculates the difference (linearly differentiated value) between the dynamic ranges of adjacent rows. The results are stored in the RAM 130 via the data selector 126.

In S59 (step of extracting a row number having a maximum dynamic range and minimum linearly differentiated value) of FIG. 25, data of the dynamic ranges of respective rows and data of the linearly differentiated values of the dynamic ranges which are stored in the RAM 130 are read out via the data selector 126, and input to the data comparator 124, which extracts a row number at which the dynamic range maximizes and the linearly differentiated value of the dynamic range minimizes (to 0 or a value close to 0).

In S60 (sensitivity referring/extraction step) of FIG. 25, the row number vs. image reading sensitivity correspondence table stored in the RAM 130 is looked up based on the extracted row number, and an image reading sensitivity, i.e., charge accumulating period set for this row is extracted.

In S61 (extracted sensitivity setting step) of FIG. 25, the data controller 122 rewrites the sensitivity setting register 127 to set the image reading sensitivity in the sensitivity setting register 127 to the extracted image reading sensitivity. In S62 (subject image reading step) of FIG. 25, normal reading operation of a subject image is executed at the

extracted image reading sensitivity set in the sensitivity setting register 127.

An example of applying the fifth embodiment of the photosensor system drive control method to a fingerprint reading apparatus will be described with reference to FIGS. 26 to 27B.

As will be described below, the fifth embodiment can effectively prevent any malfunction in optimal sensitivity extraction processing even when image data read by pre-reading operation contains an abnormal value, and the abnormal value exists on not only one pixel but across a plurality of pixels. This embodiment can also be effectively applied to a case wherein image data does not contain any abnormal value, which will be described first.

Pre-reading operation in the fifth embodiment is the same as that in the above embodiments. The fifth embodiment will exemplify a case wherein image data read by pre-reading operation is the same as image data shown in FIG. 15, and the sensitivity determination range is defined to a row/column range of 64th to 191st rows and 67th to 130th columns.

The result of extracting changes in lightness data in the 64th, 96th, 160th, and 191st rows in the sensitivity determination range and plotting them is the same as FIG. 16.

In accordance with the above-mentioned abnormal

value removing operation, the lightness data distribution of respective rows is Fourier-transformed to obtain a frequency distribution for the row number, a high-frequency component corresponding to an abnormal value or noise is removed, and the resultant data is inversely Fourier-transformed to extract only lightness data representing a main change trend in the lightness data distribution of respective rows. In this case, image data does not contain any abnormal value. Thus, even if the high-frequency component of lightness data is removed, the lightness data distribution trend does not especially change. Hence, the dynamic range distribution of respective rows is the same as that shown in FIG. 17A. Changes in the linearly differentiated values of respective rows to this dynamic range distribution are also the same as those shown in FIG. 17B. For this reason, a row number extracted under conditions that the dynamic range is maximum and the linearly differentiated value is minimum is the same as in the third embodiment, and an optimal image reading sensitivity based on the extracted row number is also the same as in the third embodiment.

The following description concerns sensitivity setting operation when image data contains an abnormal value owing to a foreign substance attached to a subject or the sensing surface of the photosensor array, a defect of the sensor element constituting

the photosensor array, or the like.

FIG. 26 is a view showing an example of image data when a subject (fingerprint) image is read while the image reading sensitivity is changed stepwise for respective rows in pre-reading operation. FIG. 27A is a graph showing the dynamic range distribution of lightness data of respective rows when a subject image has a component corresponding to a foreign substance or the like. FIG. 27B is a graph showing the dynamic range distribution of lightness data of respective rows after abnormal value removing operation according to the fifth embodiment.

As shown in FIG. 26, similar to the above-described case, a row/column range of 64th to 191st rows and 67th to 130th columns is set as a sensitivity determination range for read fingerprint image data. In this case, if an abnormal pixel IL2 relatively large enough to overlap a plurality of rows (LA to LB rows) exists in the sensitivity determination range owing to a foreign substance attached to the sensing surface of the photosensor array, a defect of the photosensor element, noise contained in image data, or the like, the lightness data of the abnormal pixel IL2 may exhibit an excessive value in a plurality of rows in comparison with peripheral pixel data, i.e., a value deviating from the change trend of peripheral pixel data. This occurs when, e.g., a relatively large black

point exists on the white background, or a relatively large white point exists on the black background, and more specifically, when the variation width or dynamic range of lightness data discretely varies in respective rows, or abnormal pixel data MC due to a foreign substance attached to the sensing surface or a defect of an element exists across a plurality of rows (LA to LB rows), as shown in FIG. 27A.

If the sensitivity setting method of the third embodiment is applied without performing abnormal value removing operation, this sensitivity setting method extracts a row in which the dynamic range of lightness data for each row is maximum and the linearly differentiated value is minimum as a row having an optimal image reading sensitivity. Thus, the dynamic ranges of rows on which the abnormal pixel IL2 continuously exists may be recognized to exhibit a maximum value with respect to the main distribution trend of the whole dynamic range. In addition, the linearly differentiated value in a region representing a continuous change exhibits a value close to 0, and may be recognized to be a minimum value. As a result, a row (row between LA and LB) containing the abnormal pixel IL2 irrelevant to a row having an original optimal image reading sensitivity may be mistaken as a row corresponding to an optimal image reading sensitivity. In this case, an improper image reading

sensitivity (e.g., charge accumulating period longer than an optimal value) is set in the photosensor system. In normal reading operation, a subject image may become, e.g., white.

To the contrary, the sensitivity setting method of the fifth embodiment can remove any abnormal value contained in lightness data by performing Fourier transformation to remove a high-frequency component corresponding to an abnormal value or noise prior to processing of obtaining the optimal value of the reading sensitivity based on the dynamic range of lightness data. As shown in FIG. 27B, an abnormal value greatly deviating from the dynamic range distribution trend of lightness data for the row number is eliminated, and only smoothed lightness data MD representing a main change trend is extracted. On the basis of the extracted lightness data MD, a row corresponding to a maximum value MA3 of the dynamic range shown in FIG. 27B is extracted as a row having an optimal image reading sensitivity under the conditions that the dynamic range is maximum and the linearly differentiated value of the dynamic range is minimum.

Even when a subject image contains the abnormal pixel IL2 relatively large enough to overlap a plurality of rows owing to a foreign substance attached to the sensing surface of the photosensor array, a defect of the photosensor element, noise contained

in image data, or the like, a row having a fine contrast corresponding to the ridge/valley pattern of a fingerprint can be reliably extracted to determine an optimal charge accumulating period. The fifth embodiment can therefore provide a fingerprint reading apparatus capable of reading a high-quality fingerprint image with almost no malfunction.

Note that the fifth embodiment executes sensitivity setting processing while the sensitivity determination range is limited to a row/column range of 64th to 191st rows and 67th to 130th columns. However, the embodiment is not limited to this, and can also be applied to a case wherein sensitivity setting processing is executed for the entire region of image data without limiting the sensitivity determination range.

According to the sensitivity setting methods of the above embodiments, a subject image is pre-read while the image reading sensitivity is changed stepwise for respective rows. A row in an optimal image reading state can be easily determined based on the dynamic range distribution of lightness data of respective rows or the linearly differentiated value of the dynamic range. An image reading sensitivity (charge accumulating period) set for this row can be set as an optimal sensitivity. Hence, the sensitivity can be set by a simple method.

Moreover, a row in an optimal image reading state can be easily determined based on lightness data obtained after an abnormal value deviating from the main change trend of lightness data is removed. An image reading sensitivity (charge accumulating period) set for this row can be set as an optimal sensitivity. Normal image reading operation of a subject image can be done at a proper sensitivity without any influence of an abnormal pixel generated by a foreign substance attached to the sensing surface of the photosensor array, a defect of the photosensor element, or the like.

Since sensitivity setting processing can be executed using an actual subject prior to normal image reading operation, no standard sample or the like need be used. Even when the brightness of a subject changes depending on changes in ambient light, an optimal image reading sensitivity can be set in accordance with changes in ambient light, and no dedicated circuit for detecting ambient light need be installed.

Even if the characteristics of the photosensor change, processing of obtaining an optimal sensitivity from image data attained by the photosensor can be performed to greatly suppress the influence of characteristic changes.

An image reading sensitivity (charge accumulating period) setting method applicable to pre-reading

operation in the above-described embodiments will be described with reference to the several views of the accompanying drawing.

FIGS. 28A to 28J are timing charts showing the first embodiment of the image reading sensitivity (charge accumulating period) setting method. This method will be explained by properly referring to the arrangement of the photosensor system shown in FIGS. 1, 2, and 31A.

According to the image reading sensitivity setting method of this embodiment, as shown in FIGS. 28A to 28D, reset pulses $\phi T1$, $\phi T2$, $\cdots$, ϕTn are simultaneously applied to respective top gate lines 101 connected to the top gate terminals TG of double-gate photosensors 10 in the row direction, thereby simultaneously starting a reset period T_{reset}, and initializing the double-gate photosensors 10 of respective rows.

The reset pulses $\phi T1$, $\phi T2$, $\cdots$, ϕTn simultaneously fall to end the reset period T_{reset}. Then, charge accumulating periods T_1, T_2, $\cdots$, T_{n-1}, T_n of the double-gate photosensors 10 on all the rows simultaneously start, and charges (holes) are generated and accumulated in the channel regions in accordance with light quantities entering the double-gate photosensors 10 of respective rows from their top gate terminal side.

As shown in FIGS. 28E to 28I, a pre-charge pulse ϕpg and readout pulses ϕB1, ϕB2, ⋯, ϕBn are applied to change stepwise the charge accumulating periods T_1, T_2, ⋯, T_{n-1}, T_n set for respective rows by a predetermined delay time T_{delay} for respective rows. In this case, the delay time T_{delay} is equal to or longer than the total time of the reset period T_{reset}, pre-charge time T_{prch}, and readout time T_{read}.

Hence, image data read at reading sensitivities different for respective rows constituting a subject image can be attained by one reading operation of the subject image in pre-reading operation performed prior to sensitivity setting processing as described in the above embodiments.

FIGS. 29A to 29J are timing charts showing the second embodiment of the image reading sensitivity (charge accumulating period) setting method. This method will be explained by properly referring to the arrangement of the photosensor system shown in FIGS. 1, 2, and 31A.

According to the image reading sensitivity setting method of this embodiment, as shown in FIGS. 29A to 29D, the reset pulses ϕT1, ϕT2, ⋯, ϕTn are sequentially applied to the respective top gate lines 101 connected to the top gate terminals TG of the double-gate photosensors 10 in the row direction at a time interval of a predetermined delay time T_{delay},

thereby starting the reset period T_{reset}, and initializing the double-gate photosensors 10 of respective rows.

The reset pulses $\phi T1$, $\phi T2$, ⋯, ϕTn fall to end the reset period T_{reset}. Then, charge accumulating periods TA_1, TA_2, ⋯, TA_{n-1}, TA_n sequentially start, and charges (holes) are generated and accumulated in the channel regions in accordance with light quantities entering the double-gate photosensors 10 of respective rows from their top gate terminal side.

As shown in FIGS. 29E to 29I, the pre-charge pulse ϕpg and readout pulses ϕBn, $\phi Bn-1$, ⋯, $\phi B2$, $\phi B1$ are applied to change stepwise the charge accumulating periods TA_1, TA_2, ⋯, TA_{n-1}, TA_n set for respective rows by the predetermined delay time T_{delay} for respective rows after the final reset pulse ϕTn falls. In this case, the delay time T_{delay} is equal to or longer than the total time of the reset period T_{reset}, pre-charge time T_{prch}, and readout time T_{read}.

By this pre-reading operation, the charge accumulating periods TA_1, TA_2, ⋯, TA_{n-1}, TA_n set for respective rows increase at a time interval twice the predetermined delay time T_{delay}, and thus image data read at reading sensitivities set at a sensitivity adjustment width of several rows or more can be obtained by reading operation of one frame.

The image reading sensitivity (charge accumulating

period) setting method applied to sensitivity setting processing according to the present invention is not limited to the above embodiments. As far as image data of a subject image can be obtained at different reading sensitivities, e.g., a series of processes described in the prior art: reset operation → charge accumulating operation → pre-charge operation → readout operation can be repeated a plurality of number of times at different reading sensitivities, thereby obtaining image data at different reading sensitivities. Alternatively, any other methods may also be employed.

The effective voltages of signals applied to the top and bottom gates TG and BG of the double-gate photosensor 10 will be described.

As is apparent from FIGS. 28A to 28H, 29A to 29H, and 33A to 33C, the top gate TG receives a high-level signal voltage Vtgh as a reset pulse only for a very short time (T_{reset}), and a low-level signal voltage Vtgl for the remaining relatively long period in pre-reading operation and image reading operation. In the pre-reading operation and image reading periods, the effective voltage applied to the top gate TG greatly shifts to the low-level side. Since an optimal charge accumulating period set for image reading operation is changed and set in accordance with the ambient illuminance or the like if necessary, the effective voltage applied to the top gate TG inevitably

varies.

In pre-reading operation and image reading operation, the bottom gate BG receives a high-level signal voltage Vbgh only for a very short time (T_{read}), and a low-level signal voltage Vbgl for the remaining relatively long period. In the pre-reading and image reading periods, the effective voltage applied to the bottom gate BG also greatly shifts to the low-level side. Since an optimal charge accumulating period set for image reading operation is changed and set in accordance with the ambient illuminance or the like if necessary, the effective voltage applied to the bottom gate BG inevitably varies.

If such a voltage shifted to a voltage of a specific polarity is kept applied to the gate electrode, the gate electrode traps holes to degrade the element characteristics of the double-gate photosensor and change the sensitivity characteristics.

To prevent this, an effective voltage adjusting period for correcting effective voltages applied to the top and bottom gates TG and BG is set after the pre-reading and image reading periods. During the effective voltage adjusting period, e.g., predetermined correction signals for setting an effective voltage applied to the top gate TG to an optimal value Vte of the effective voltage on the top gate side set in accordance with the sensitivity characteristics of the

double-gate photosensor, and an effective voltage applied to the bottom gate BG to an optimal value Vbe of the effective voltage on the bottom gate side are applied. This can suppress changes in sensitivity characteristics caused by degradation in the element characteristics of the photosensor, and can improve the reliability of the photosensor system.

A photosensor system drive control method according to the present invention when the effective voltage adjusting period is set after the pre-reading and image reading periods, as described above, will be described with reference to FIGS. 30A to 30H.

FIGS. 30A to 30H are timing charts showing an embodiment when the effective voltage adjusting period is set after the pre-reading and image reading periods.

As the drive control method during the pre-reading period, the drive control method in FIGS. 29A to 29H described above is applied. The same reference numerals denote the same parts, and a description thereof will be omitted. The reset pulses $\phi T1$, $\phi T2$, ⋯, ϕTn are pulse signals whose high and low levels are signal voltages Vtgh and Vtgl, respectively. The readout pulses $\phi B1$, $\phi B2$, ⋯, ϕBn are pulse signals whose high and low levels are signal voltages Vbgh and Vbgl, respectively. As the drive control method during the pre-reading period, the operation shown in FIGS. 28A to 28H may be applied. The present invention

is not limited to these methods.

The drive control method during the image reading period is based on the conventional photosensor system drive control method shown in FIGS. 33A to 33D. To shorten the operation time, photosensors are driven by overlapping the charge accumulating periods of respective rows at timings so as not to overlap reset, pre-charge, and readout pulses. That is, as shown in FIGS. 30A to 30C, the reset pulses $\phi T1$, $\phi T2$, $\cdots$, ϕTn are sequentially applied to the respective top gate lines 101 connected to the top gate terminals TG of the double-gate photosensors 10 in the row direction, thereby starting the reset period T_{reset}, and initializing the double-gate photosensors 10 of respective rows. Similar to the above-described pre-reading operation, the reset pulses $\phi T1$, $\phi T2$, $\cdots$, ϕTn are pulse signals whose high and low levels are the signal voltages Vtgh and Vtgl, respectively. Except for timings at which the reset pulses $\phi T1$, $\phi T2$, $\cdots$, ϕTn of high-level Vtgh are applied, the low-level signal voltage Vtgl is applied.

The reset pulses $\phi T1$, $\phi T2$, $\cdots$, ϕTn fall to end the reset period T_{reset}. Then, optimal light accumulating periods Ta obtained by each embodiment for respective rows based on pre-reading operation sequentially start, and charges (holes) are generated and accumulated in the channel regions in accordance

with light quantities entering the double-gate photosensors 10 from their top gate electrode side. As shown in FIG. 30G, pre-charge operation of applying the pre-charge signal ϕpg to start the pre-charge period T_{prch}, and applying the pre-charge voltage V_{prch} to the data line 103 to cause the drain electrode of the double-gate photosensor 10 to hold a predetermined voltage is performed during the light accumulating period Ta. As shown in FIGS. 30D to 30F, the readout pulses ϕB1, ϕB2, ⋯, ϕBn are sequentially applied in units of rows to the bottom gate lines 102 of double-gate photosensors 10 in which the optimal light accumulating period Ta and pre-charge period T_{prch} end. Then, the readout period T_{read} starts, and voltage changes VD corresponding to charges accumulated in the double-gate photosensors 10 are read out from the output circuit section 113 via the data lines 103, as shown in FIG. 30H. Similar to pre-reading operation described above, the readout pulses ϕB1, ϕB2, ⋯, ϕBn are pulse signals whose high and low levels are at the signal voltages Vbgh and Vbgl, respectively. Till timings at which the readout pulses ϕB1, ϕB2, ⋯, ϕBn of high-level Vbgh are applied, the low-level signal voltage Vbgl has been applied.

After image reading operation is completed for all the rows, effective voltage adjustment operation of adjusting the shifts of the effective voltages of

signals applied to each gate electrode in the pre-reading and image reading periods and optimizing the effective voltages is executed in the effective voltage adjusting period. More specifically, as shown in FIGS. 30A to 30C, the top gate line 101 of each row receives a correction signal having a high-level period (Ttph) and low-level period (Ttpl) so as to attain a predetermined effective voltage capable of adjusting the effective voltage of a signal voltage applied to the top gate line 101, i.e., top gate terminal TG of the double-gate photosensor 10 in response to a reset pulse in the pre-reading and image reading periods to an optimal value Vte set in advance in accordance with the sensitivity characteristics of the double-gate photosensor 10.

Similarly, the bottom gate line 102 of each row receives a correction signal having a high-level period (Tbph) and low-level periods (Tbpla and Tbplb) so as to attain a predetermined effective voltage capable of adjusting the effective voltage of a signal voltage applied to the bottom gate line 102, i.e., bottom gate terminal BG of the double-gate photosensor 10 in response to a readout pulse to an optimal value Vbe set in advance in accordance with the sensitivity characteristics of the double-gate photosensor 10.

As a result, the effective values of voltages applied to the top and bottom gates TG and BG of the

photosensor element can be set to optimal values to suppress changes in sensitivity characteristics caused by degradation in the element characteristics of the photosensor, and to improve the reliability of the photosensor system.

WHAT IS CLAIMED IS:

1. A photosensor system comprising

a photosensor array constituted by two-dimensionally arraying a plurality of photosensors,

image reading means for reading a subject image at a predetermined reading sensitivity by the photosensor array:

pre-reading means for reading the subject image prior to image reading operation while changing an image reading sensitivity of the photosensor array at a plurality of stages;

optimal reading sensitivity extraction means for extracting an optimal image reading sensitivity suitable for the image reading operation on the basis of a predetermined measurement amount relating to an image pattern of the subject image read by said pre-reading means; and

reading sensitivity setting means for setting the optimal image reading sensitivity to a reading sensitivity of said image reading means.

2. A system according to claim 1, wherein said reading by the image reading means is executed by setting different image reading sensitivities stepwise for respective rows of the photosensor array and reading the subject image.

3. A system according to claim 1, wherein the predetermined measurement amount in said reading

sensitivity extraction means is lightness data corresponding to the image pattern of the subject image read by pre-reading operation.

4. A system according to claim 1, wherein the image reading sensitivity of the photosensor array is set by adjusting a charge accumulating period of the photosensor.

5. A system according to claim 1, which further comprises, in said image reading means and said pre-reading means in the photosensor array, effective voltage adjustment means for applying to each photosensor a correction signal for setting to optimal values effective voltages of signal voltages applied to the each photosensor.

6. A system according to claim 1, wherein said reading sensitivity extraction means comprises:

measurement amount comparison means for extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by pre-reading operation;

dynamic range calculation means for calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity; and

maximum dynamic range extraction means for

extracting an image reading sensitivity having a maximum dynamic range among dynamic ranges of measurement amounts calculated for each image reading sensitivity.

7. A system according to claim 6, wherein said measurement amount comparison means extracts the maximum and minimum values of the measurement amount in a predetermined column range of each row.

8. A system according to claim 1, wherein said reading sensitivity extraction means comprises:

displacement calculation means for calculating a displacement of the measurement amount relating to the image pattern of the subject image between image reading sensitivities on the basis of the subject image read by pre-reading operation; and

maximum displacement extraction means for extracting an image reading sensitivity having a maximum displacement among displacements of measurement amounts between image reading sensitivities.

9. A system according to claim 8, wherein said displacement calculation means calculates a differentiated value of the measurement amount on predetermined columns of each row.

10. A system according to claim 1, wherein said reading sensitivity extraction means comprises:

measurement amount comparison means for extracting maximum and minimum values of the measurement amount

relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by pre-reading operation;

dynamic range calculation means for calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity; and

maximum dynamic range extraction means for extracting an image reading sensitivity at which the dynamic range of the measurement amount for each image reading sensitivity maximizes and a displacement of the dynamic range between image reading sensitivities minimizes.

11. A system according to claim 1, which further comprises abnormal value removing means for removing an abnormal value deviating from a main change trend of the measurement amount, from the measurement amount relating to the image pattern of the subject image read by pre-reading operation.

12. A system according to claim 11, wherein said abnormal value removing means removes the abnormal value by performing Fourier transformation for the measurement amount and removing a predetermined high-frequency component from the frequency-converted measurement amount.

13. A system according to claim 1, which further

comprises:

measurement amount comparison means for extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by pre-reading operation;

dynamic range calculation means for calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity;

specific value extraction means for extracting for each image reading sensitivity a specific value at which the dynamic range of the measurement amount for each image reading sensitivity maximizes and a displacement of the dynamic range between image reading sensitivities maximizes; and

abnormality determination means for determining presence/absence of an abnormality contained in the subject image on the basis of the specific value.

14. A system according to claim 1, wherein

each photosensor has a source electrode and drain electrode formed via a channel region made from a semiconductor layer, and a top gate electrode and bottom gate electrode formed at least on and below the channel region via insulating films,

either of the top gate electrode and bottom gate electrode is used as a light irradiation side, and

charges corresponding to a light quantity irradiated from the light irradiation side are generated and accumulated in the channel region.

15. A drive control method for a photosensor system having a photosensor array constituted by two-dimensionally arraying a plurality of photosensors comprising the steps of:

executing pre-reading operation of reading a subject image while changing an image reading sensitivity of the photosensor array at a plurality of stages;

extracting an image reading sensitivity suitable for reading operation of the subject image on the basis of a predetermined measurement amount relating to an image pattern of the subject image read by the pre-reading operation;

setting the extracted image reading sensitivity as a reading sensitivity in the reading operation of the subject image; and

executing image reading operation of reading the subject image at the set reading sensitivity.

16. A method according to claim 15, wherein the pre-reading operation is executed by setting different image reading sensitivities stepwise for respective rows of the photosensor array and reading the subject image.

17. A method according to claim 15, wherein the

predetermined measurement amount is lightness data corresponding to the image pattern of the subject image read by the pre-reading operation.

18. A method according to claim 15, wherein the image reading sensitivity of the photosensor array is set by adjusting a charge accumulating period of the photosensor.

19. A method according to claim 15, wherein the step of extracting the image reading sensitivity comprises the steps of:

extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by the pre-reading operation;

calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity; and

extracting an image reading sensitivity having a maximum dynamic range among dynamic ranges of measurement amounts calculated for each image reading sensitivity.

20. A method according to claim 15, wherein the step of extracting the image reading sensitivity comprises the steps of:

calculating a displacement of the measurement

amount relating to the image pattern of the subject image between image reading sensitivities on the basis of the subject image read by the pre-reading operation; and

extracting an image reading sensitivity at which a displacement of the measurement amount between image reading sensitivities maximizes.

21. A method according to claim 15, wherein the step of extracting the image reading sensitivity comprises the steps of:

extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by the pre-reading operation;

calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity; and

extracting an image reading sensitivity at which the dynamic range of the measurement amount for each image reading sensitivity maximizes and a displacement of the dynamic range between image reading sensitivities minimizes.

22. A method according to claim 15, wherein the step of extracting the image reading sensitivity comprises the steps of:

extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by the pre-reading operation;

calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity;

extracting a specific value at which the dynamic range of the measurement amount for each image reading sensitivity maximizes and a displacement of the dynamic range between image reading sensitivities maximizes; and

determining presence/absence of an abnormality contained in the subject image on the basis of the specific value.

23. A method according to claim 15, wherein the step of extracting the image reading sensitivity comprises the step of:

removing an abnormal value deviating from a main change trend of the measurement amount, from the measurement amount relating to the image pattern of the subject image for each image reading sensitivity.

24. A method according to claim 23, wherein the step of removing the abnormal value from the measurement amount comprises the step of:

performing Fourier transformation for the measurement amount and removing a predetermined high-frequency component from the frequency-converted measurement amount.

25. A method according to claim 15, wherein

each photosensor has a source electrode and drain electrode formed via a channel region made from a semiconductor layer, and a top gate electrode and bottom gate electrode formed at least on and below the channel region via insulating films,

either of the top gate electrode and bottom gate electrode is used as a light irradiation side, and

charges corresponding to a light quantity irradiated from the light irradiation side are generated and accumulated in the channel region.

ABSTRACT OF THE DISCLOSURE

A photosensor system having a photosensor array constituted by two-dimensionally arraying a plurality of photosensors includes a driver circuit for supplying a drive signal to the photosensors, and a controller for controlling reading operation of a subject image and sensitivity setting. Before the start of normal reading operation of a subject image, pre-reading operation of changing the image reading sensitivity at a plurality of stages for respective rows is executed. A row in an optimal image reading state is easily determined based on the dynamic range distribution of the lightness data of read image data or a dynamic range distribution from which an abnormal value deviating from the main change trend of lightness data is removed, and the linearly differentiated value of the dynamic range. An image reading sensitivity set for this row is set as an optimal sensitivity. This can simplify sensitivity setting processing and shorten the required time. In addition, an optimal image reading sensitivity can be set in accordance with changes in ambient light and changes in the characteristics of the photosensor. Since a row corresponding to an appropriate image reading sensitivity can be extracted without any influence of an abnormal pixel generated by a foreign substance attached to the sensing surface of the photosensor array, a defect of

the photosensor element, or the like, a reliable reading sensitivity setting method can be provided.

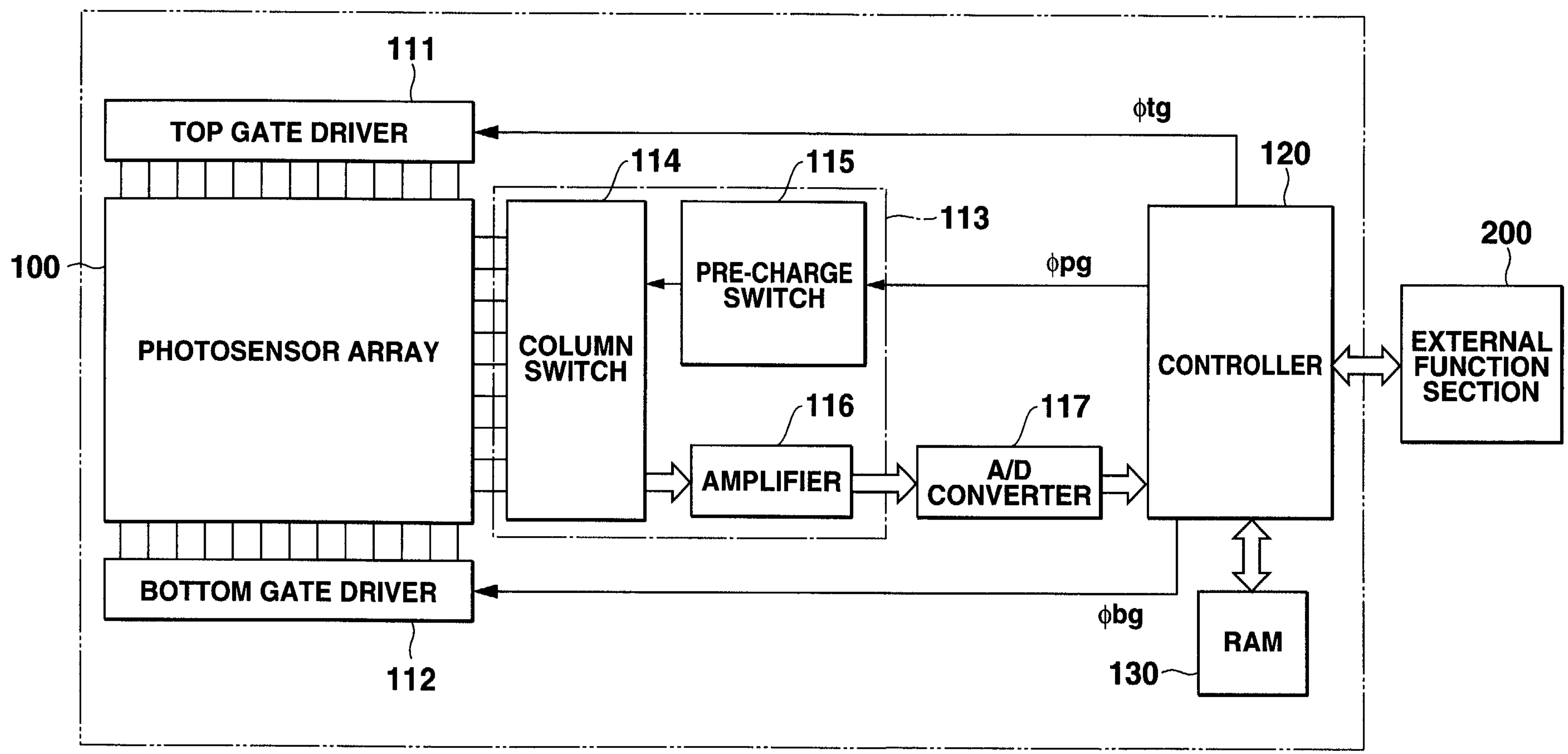
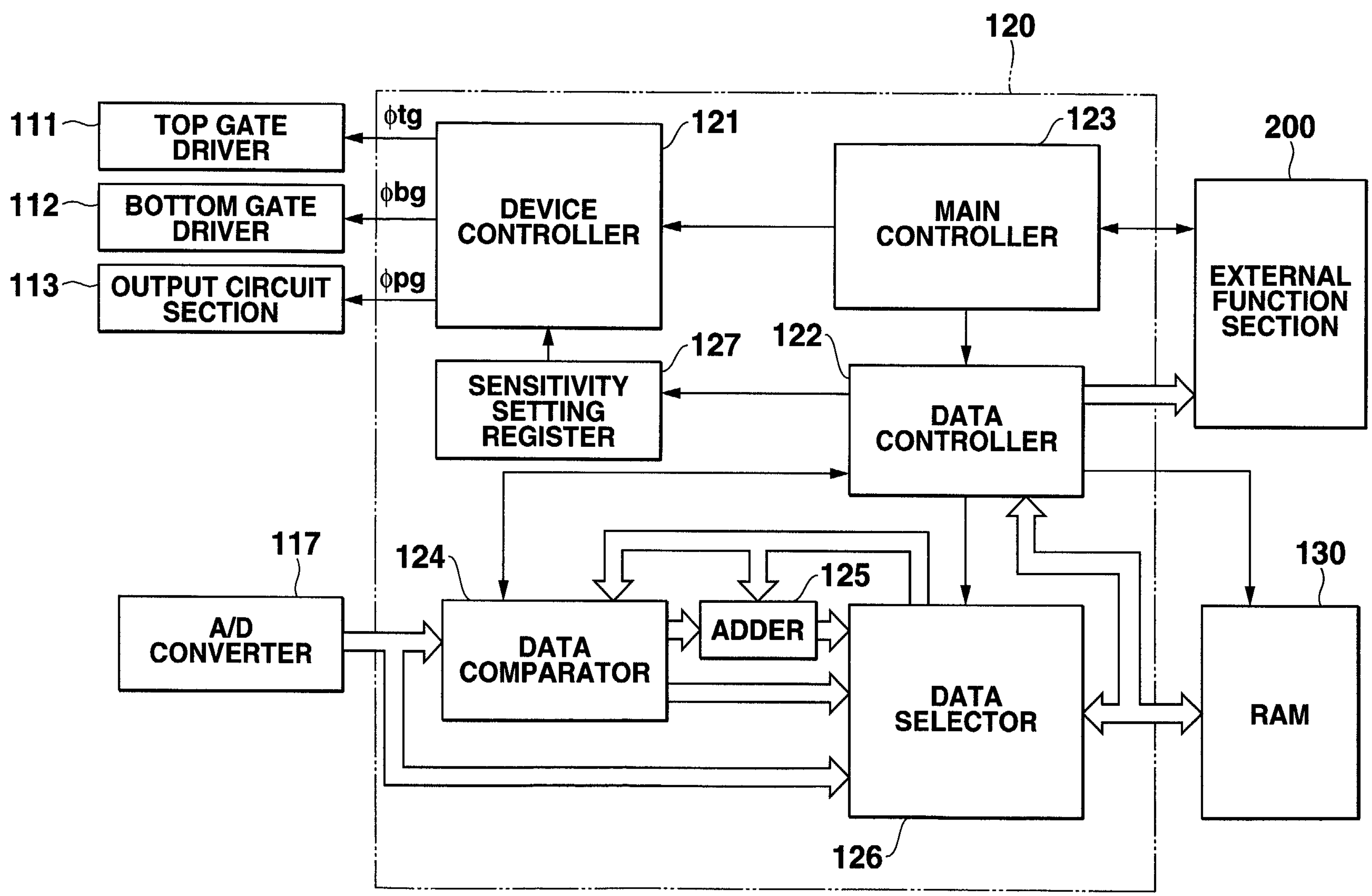

111
TOP GATE DRIVER
φtg
114
115
120
113
100
PRE-CHARGE SWITCH
φpg
200
PHOTOSENSOR ARRAY
COLUMN SWITCH
CONTROLLER
EXTERNAL FUNCTION SECTION
116
117
AMPLIFIER
A/D CONVERTER
BOTTOM GATE DRIVER
φbg
RAM
130
112

FIG.1



120
111
TOP GATE DRIVER
112
BOTTOM GATE DRIVER
113
OUTPUT CIRCUIT SECTION
φtg
φbg
φpg
121
DEVICE CONTROLLER
123
MAIN CONTROLLER
200
EXTERNAL FUNCTION SECTION
127
SENSITIVITY SETTING REGISTER
122
DATA CONTROLLER
117
A/D CONVERTER
124
DATA COMPARATOR
125
ADDER
DATA SELECTOR
126
130
RAM

FIG.2

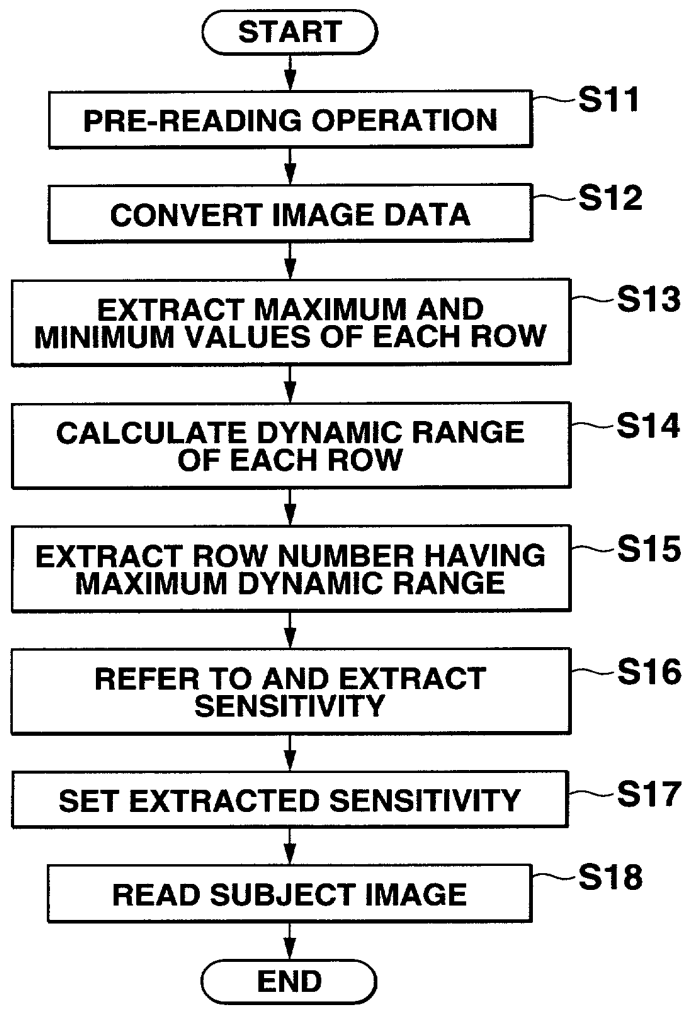

START
PRE-READING OPERATION
S11
CONVERT IMAGE DATA
S12
EXTRACT MAXIMUM AND MINIMUM VALUES OF EACH ROW
S13
CALCULATE DYNAMIC RANGE OF EACH ROW
S14
EXTRACT ROW NUMBER HAVING MAXIMUM DYNAMIC RANGE
S15
REFER TO AND EXTRACT SENSITIVITY
S16
SET EXTRACTED SENSITIVITY
S17
READ SUBJECT IMAGE
S18
END

FIG.3

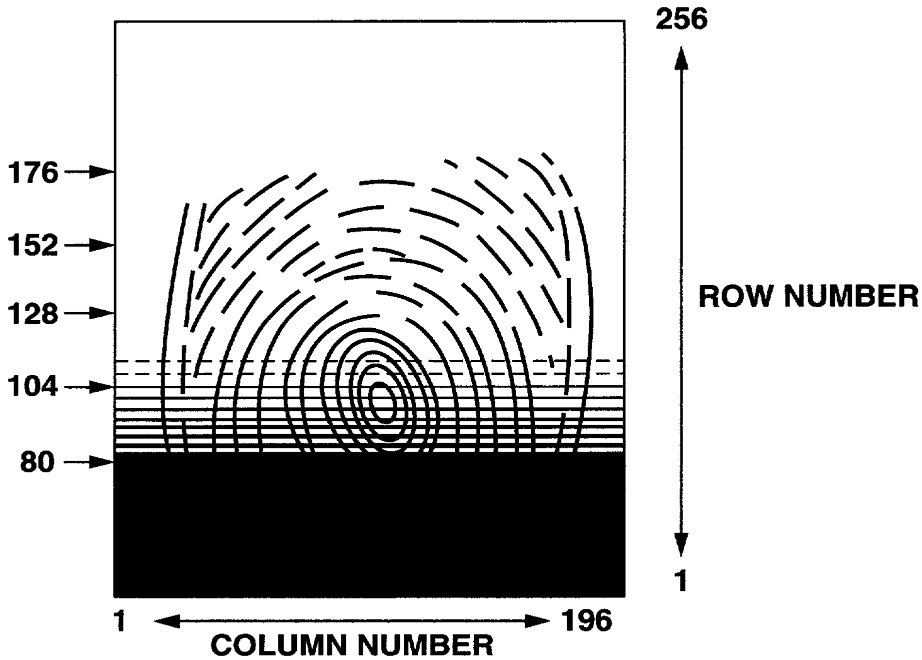
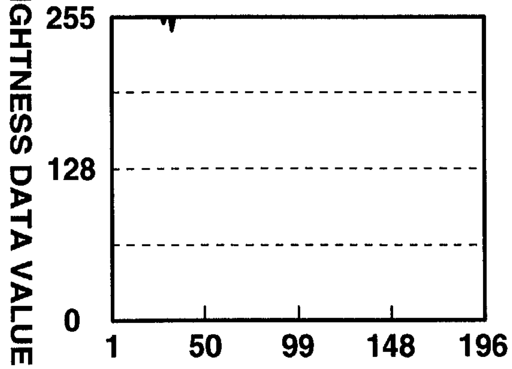


FIG.4

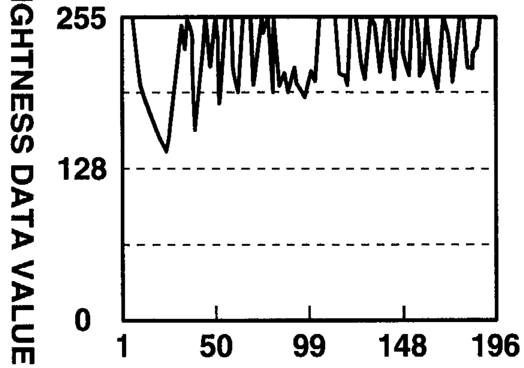
MEASUREMENT DATA
OF 176TH ROW



COLUMN NUMBER

FIG.5A

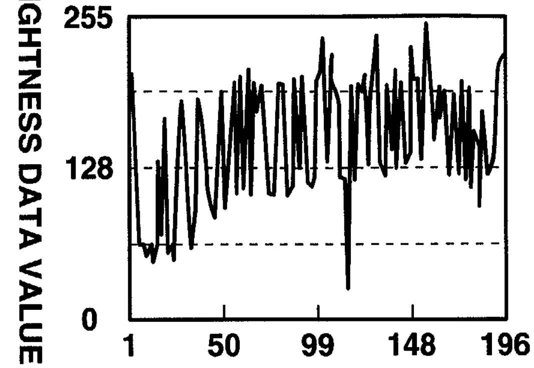
MEASUREMENT DATA
OF 152TH ROW



COLUMN NUMBER

FIG.5B

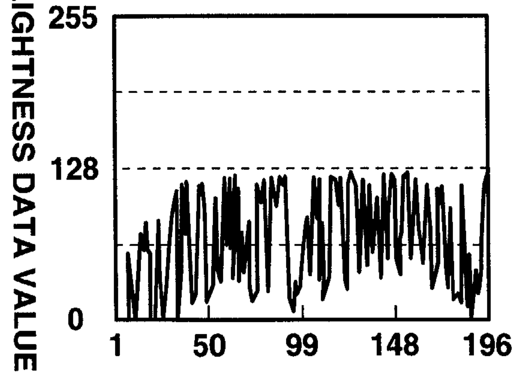
MEASUREMENT DATA
OF 128TH ROW



COLUMN NUMBER

FIG.5C

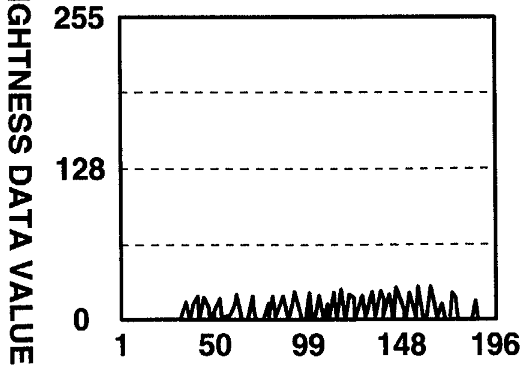
MEASUREMENT DATA
OF 104TH ROW



COLUMN NUMBER

FIG.5D

MEASUREMENT DATA
OF 80TH ROW



COLUMN NUMBER

FIG.5E

FIG.6A

ROW NUMBER	80TH ROW	104TH ROW	128TH ROW	152ND ROW	176TH ROW
MAXIMUM VALUE	25	127	251	255	255
MINIMUM VALUE	0	0	27	153	249
DYNAMIC RANGE	25	127	224	102	6

FIG.6B

ROW NUMBER	1ST ROW	. . .	128TH ROW	. . .	256TH ROW
CHARGE ACCUMLATING PERIOD	T_1	. . .	T_{128}	. . .	T_{256}

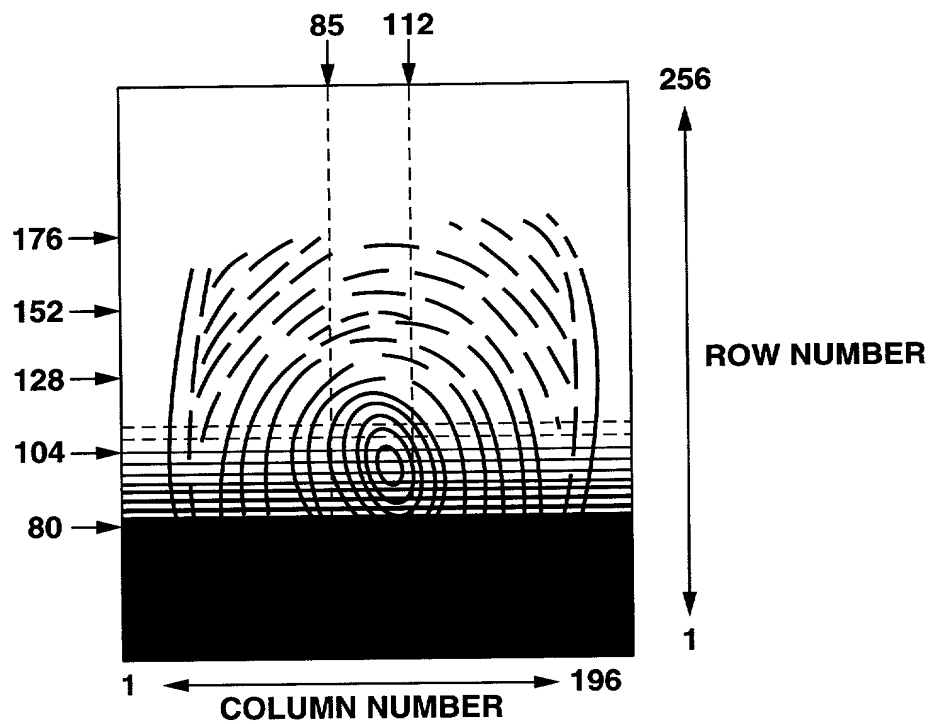


FIG.7

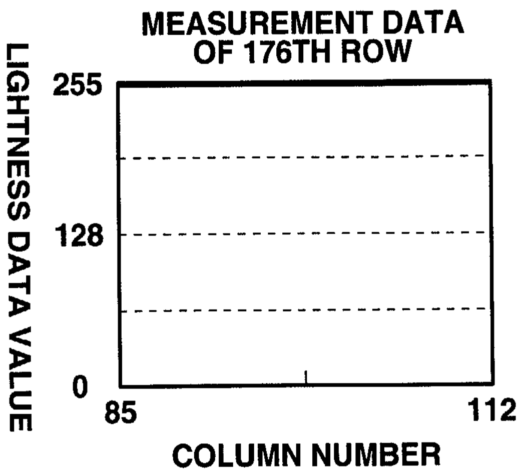


FIG.8A

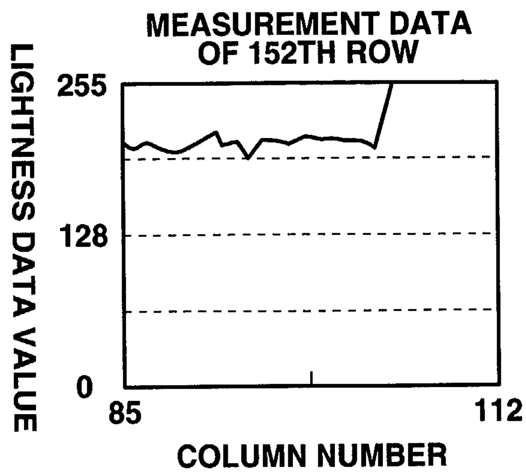


FIG.8B

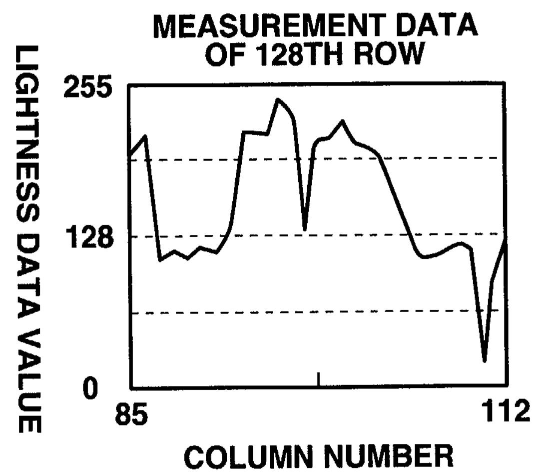


FIG.8C

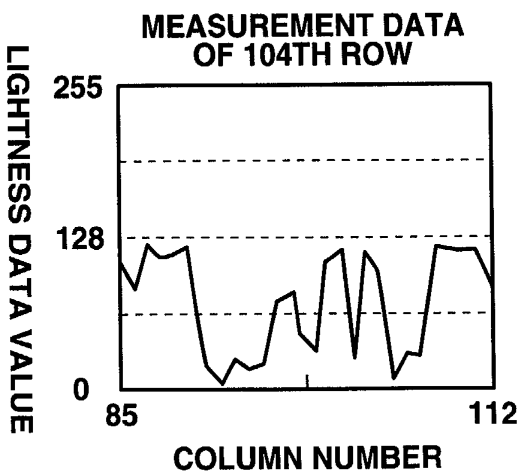


FIG.8D

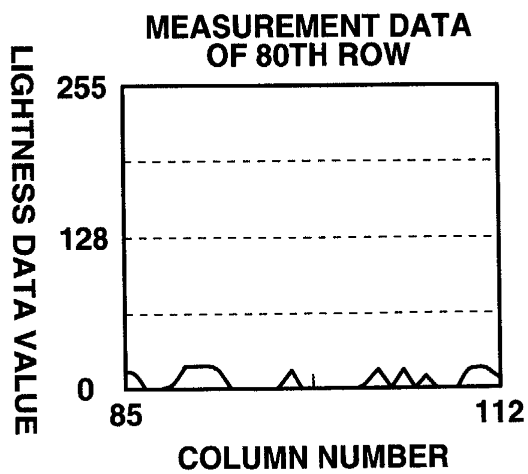


FIG.8E

FIG.9A

ROW NUMBER	80TH ROW	104TH ROW	128TH ROW	152ND ROW	176TH ROW
MAXIMUM VALUE	23	117	243	255	255
MINIMUM VALUE	0	9	27	193	255
DYNAMIC RANGE	23	108	216	62	0

FIG.9B

ROW NUMBER	1ST ROW	· · ·	128TH ROW	· · ·	256TH ROW
CHARGE ACCUMLATING PERIOD	T_1	· · ·	T_{128}	· · ·	T_{256}

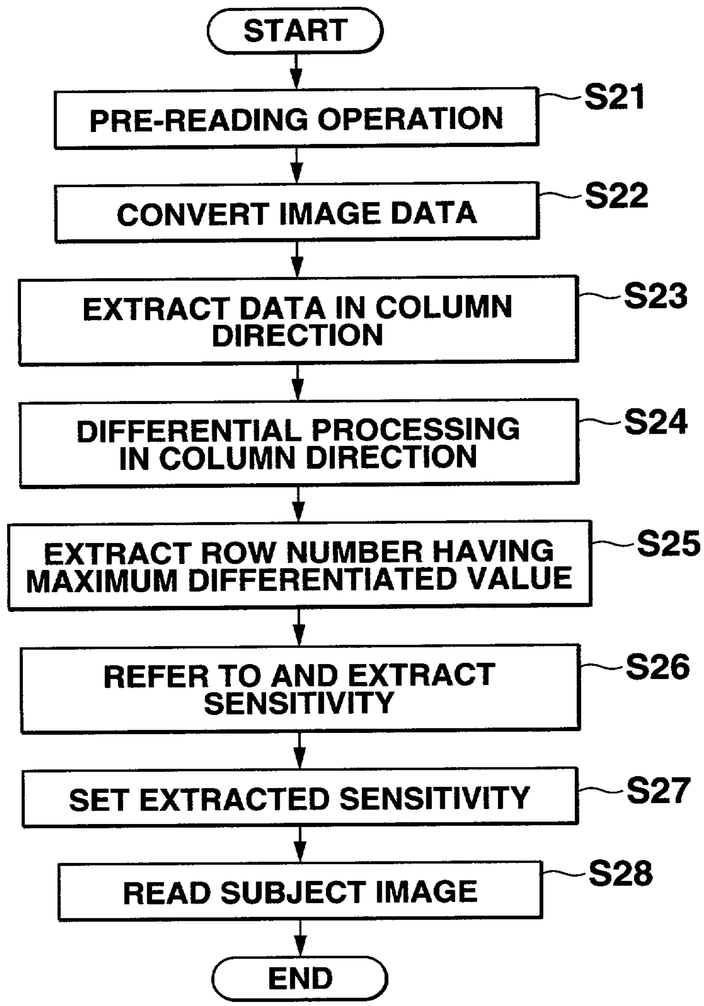

START
PRE-READING OPERATION
S21
CONVERT IMAGE DATA
S22
EXTRACT DATA IN COLUMN DIRECTION
S23
DIFFERENTIAL PROCESSING IN COLUMN DIRECTION
S24
EXTRACT ROW NUMBER HAVING MAXIMUM DIFFERENTIATED VALUE
S25
REFER TO AND EXTRACT SENSITIVITY
S26
SET EXTRACTED SENSITIVITY
S27
READ SUBJECT IMAGE
S28
END

FIG.10

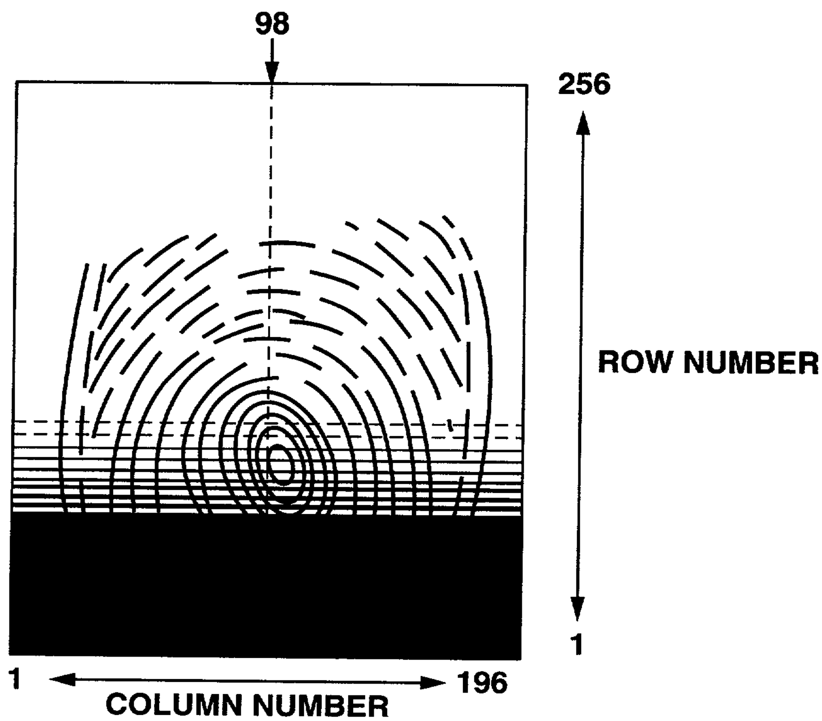


FIG.11

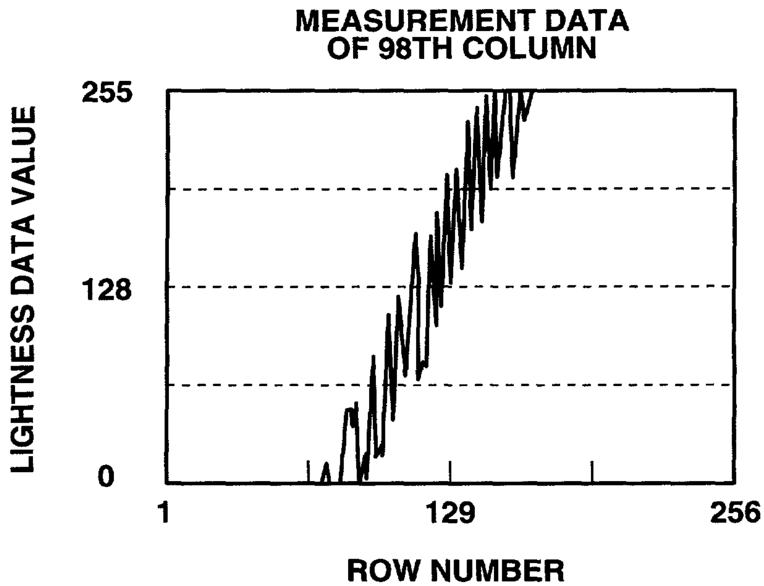


FIG.12A

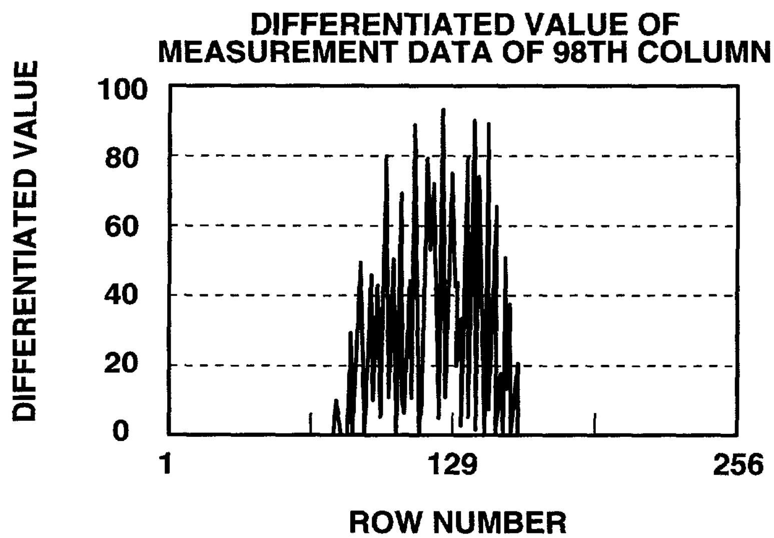


FIG.12B

FIG.13A

ROW NUMBER	. . .	121ST ROW	122ND ROW	123RD ROW	124TH ROW	125TH ROW	126TH ROW	127TH ROW	128TH ROW	129TH ROW	. . .
DIFFERENTIATED VALUE	. . .	80	53	72	5	95	11	76	20		. . .

FIG.13B

ROW NUMBER	. . .	121ST ROW	122ND ROW	123RD ROW	124TH ROW	125TH ROW	126TH ROW	127TH ROW	128TH ROW	129TH ROW	. . .
CHARGE ACCUMLATING PERIOD	. . .	T_{121}	T_{122}	T_{123}	T_{124}	T_{125}	T_{126}	T_{127}	T_{128}	T_{129}	. . .

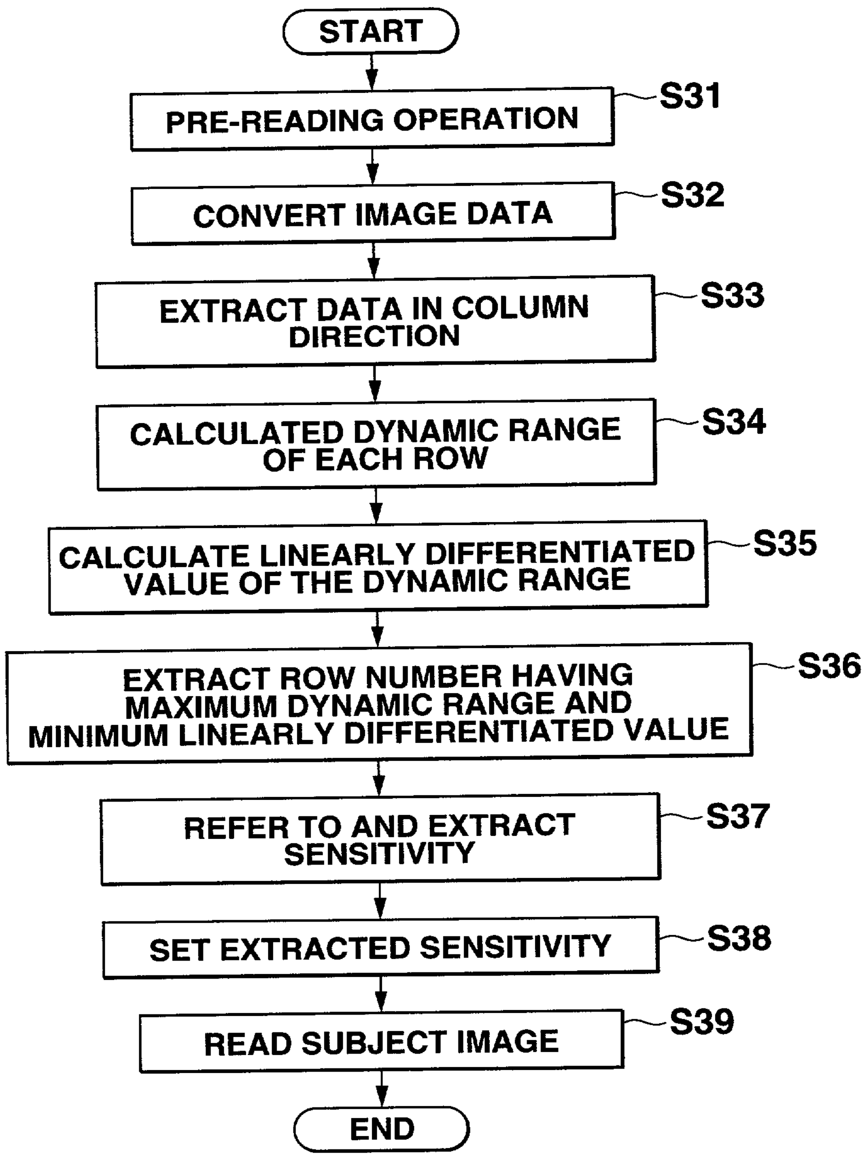

START
PRE-READING OPERATION
S31
CONVERT IMAGE DATA
S32
EXTRACT DATA IN COLUMN DIRECTION
S33
CALCULATED DYNAMIC RANGE OF EACH ROW
S34
CALCULATE LINEARLY DIFFERENTIATED VALUE OF THE DYNAMIC RANGE
S35
EXTRACT ROW NUMBER HAVING MAXIMUM DYNAMIC RANGE AND MINIMUM LINEARLY DIFFERENTIATED VALUE
S36
REFER TO AND EXTRACT SENSITIVITY
S37
SET EXTRACTED SENSITIVITY
S38
READ SUBJECT IMAGE
S39
END

FIG.14

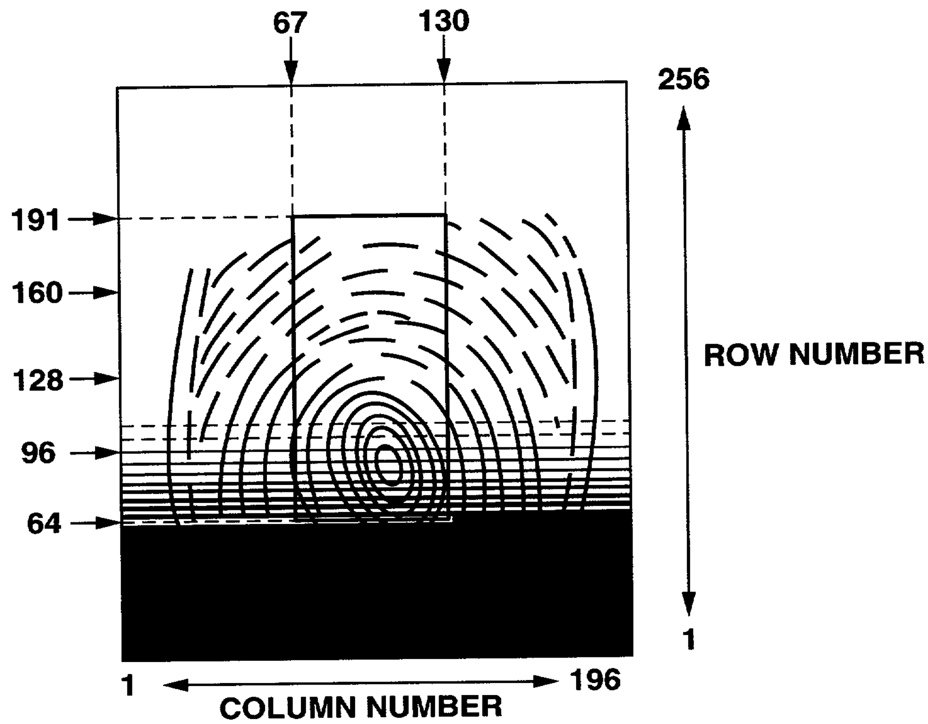


FIG.15

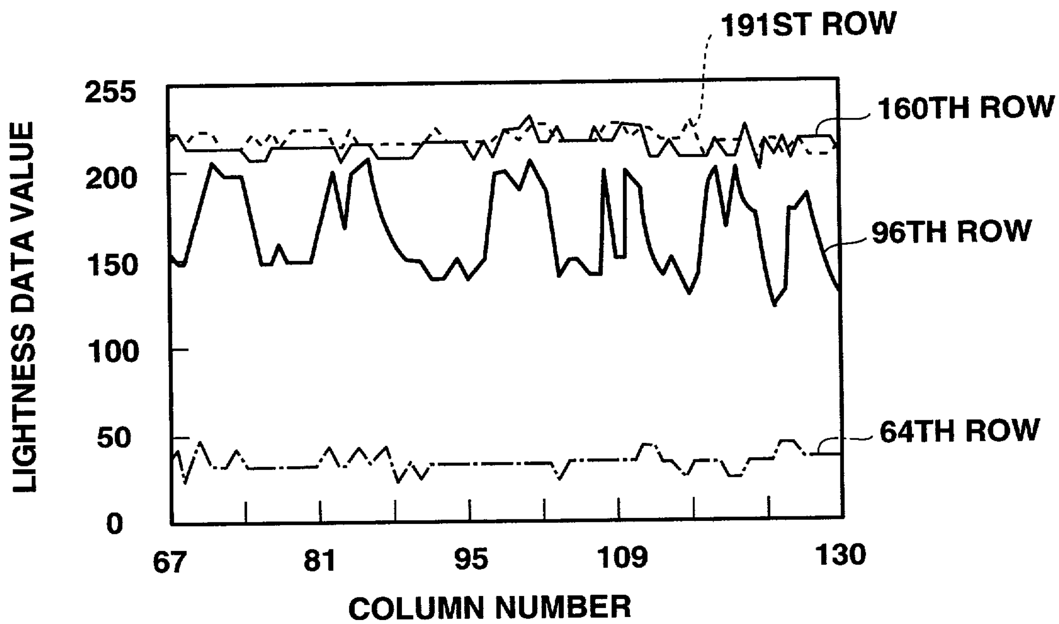

191ST ROW
160TH ROW
96TH ROW
64TH ROW
255
200
150
100
50
0
LIGHTNESS DATA VALUE
67
81
95
109
130
COLUMN NUMBER

FIG.16

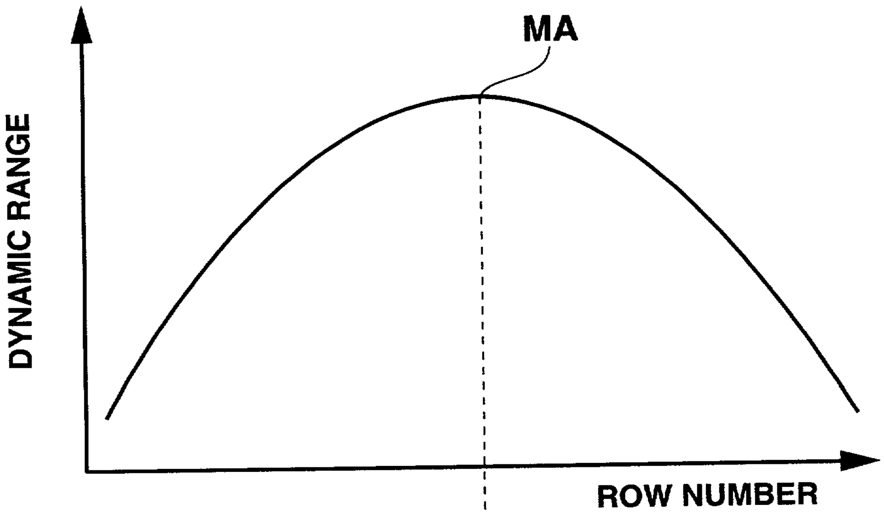


FIG.17A

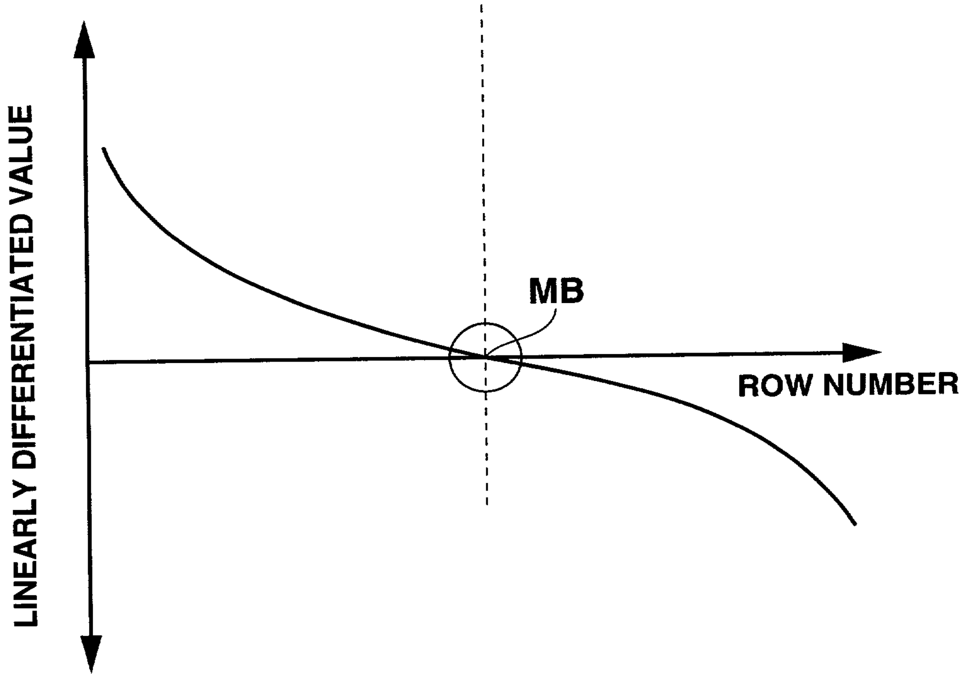


FIG.17B

FIG.18A

ROW NUMBER	64TH ROW	. . .	L_{k-1} ROW	L_k ROW	L_{k+1} ROW	. . .	191ST ROW
MAXIMUM VALUE	X_{64}	. . .	X_{K-1}	X_K	X_{K+1}	. . .	X_{191}
MINIMUM VALUE	Y_{64}	. . .	Y_{K-1}	Y_K	Y_{K+1}	. . .	Y_{191}
DYNAMIC RANGE	R_{64}	. . .	R_{K-1}	R_K(MAX)	R_{K+1}	. . .	R_{191}
LINEARLY DIFFERENTIATED VALUE	. . .	D_{k-2}	D_{k-1}(MIN)	D_k	D_{k+1}	. . .	

FIG.18B

ROW NUMBER	64TH ROW	. . .	L_{k-1} ROW	L_k ROW	L_{k+1} ROW	. . .	191ST ROW
CHARGE ACCUMLATING PERIOD	T_{64}	. . .	T_{k-1}	T_k	T_{k+1}	. . .	T_{191}

FIG.19A

ROW NUMBER	64TH ROW	. . .	L_{k-1} ROW	L_k ROW	L_{k+1} ROW	. . .	191ST ROW
MAXIMUM VALUE	X_{64}	. . .	X_{K-1}	X_K	X_{K+1}	. . .	X_{191}
MINIMUM VALUE	Y_{64}	. . .	Y_{K-1}	Y_K	Y_{K+1}	. . .	Y_{191}
DYNAMIC RANGE	R_{64}	. . .	R_{K-1}	$R_{K(MAX)}$	R_{K+1}	. . .	R_{191}

FIG.19B

ROW NUMBER	64TH ROW	. . .	L_{k-1} ROW	L_k ROW	L_{k+1} ROW	. . .	191ST ROW
CHARGE ACCUMLATING PERIOD	T_{64}	. . .	T_{k-1}	T_k	T_{k+1}	. . .	T_{191}

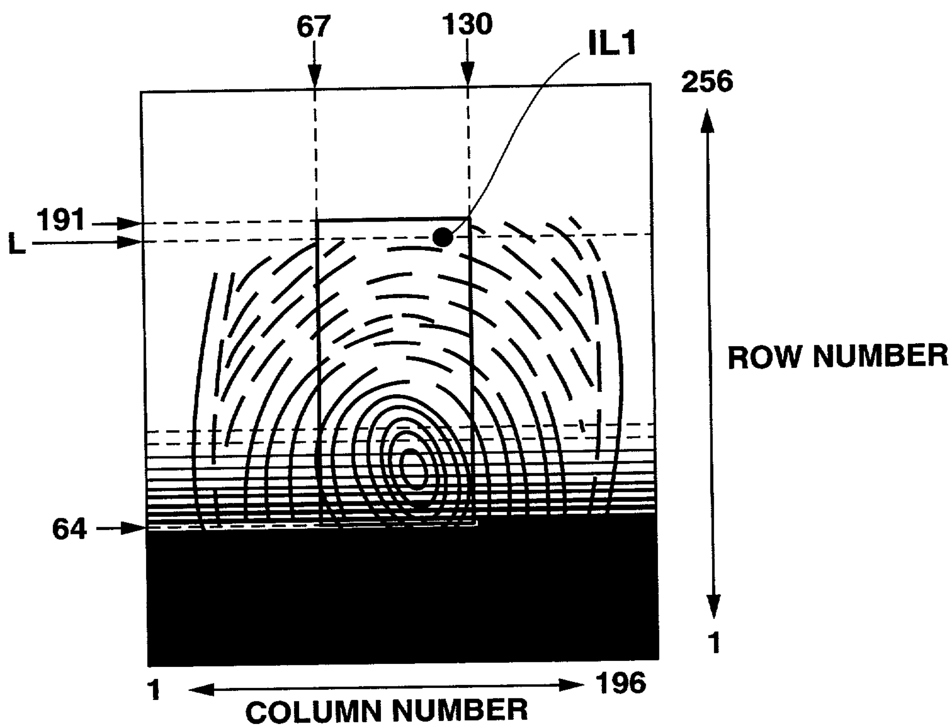


FIG.20

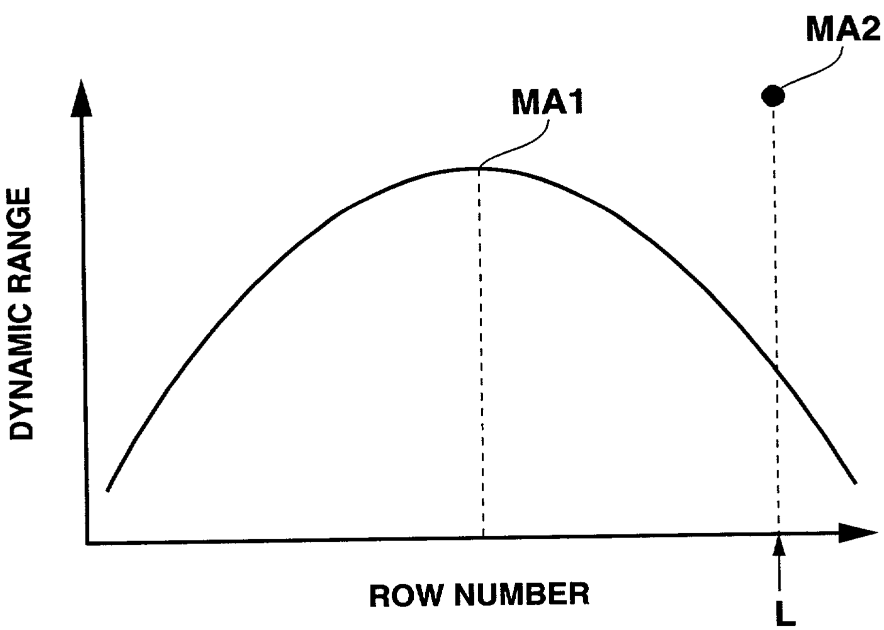


FIG.21

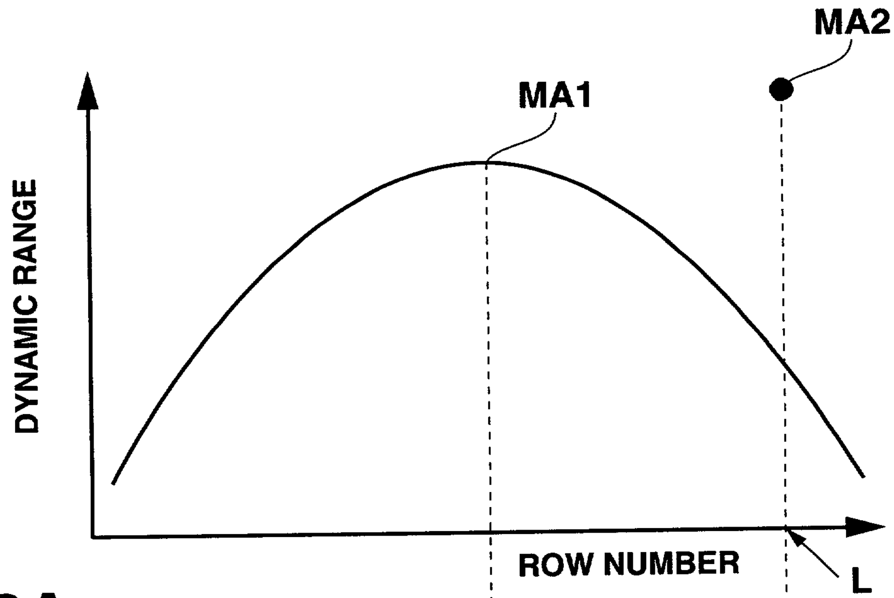


FIG.22A

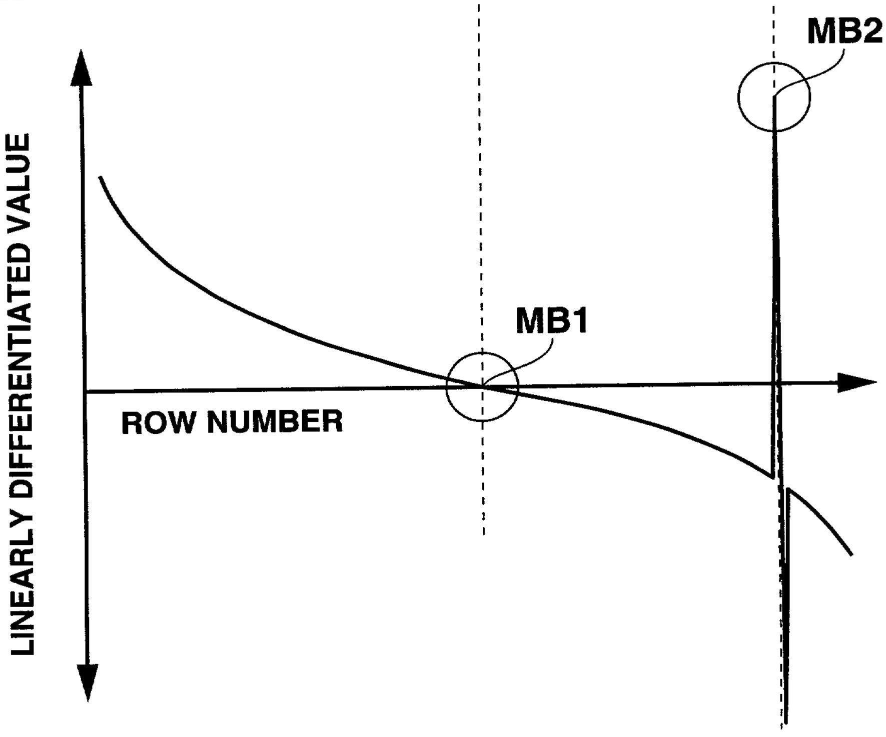
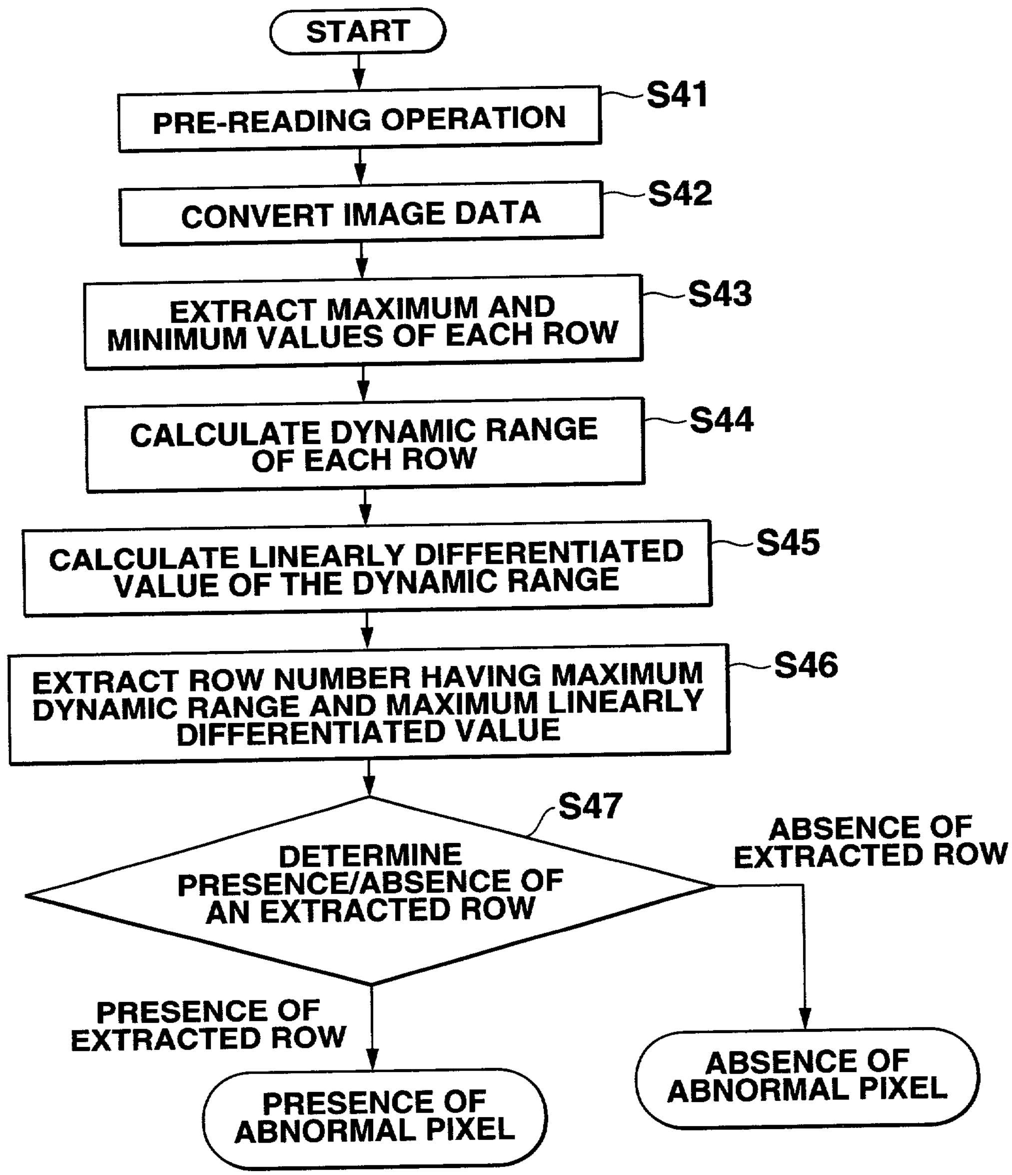


FIG.22B



START
PRE-READING OPERATION
S41
CONVERT IMAGE DATA
S42
EXTRACT MAXIMUM AND MINIMUM VALUES OF EACH ROW
S43
CALCULATE DYNAMIC RANGE OF EACH ROW
S44
CALCULATE LINEARLY DIFFERENTIATED VALUE OF THE DYNAMIC RANGE
S45
EXTRACT ROW NUMBER HAVING MAXIMUM DYNAMIC RANGE AND MAXIMUM LINEARLY DIFFERENTIATED VALUE
S46
S47
DETERMINE PRESENCE/ABSENCE OF AN EXTRACTED ROW
ABSENCE OF EXTRACTED ROW
PRESENCE OF EXTRACTED ROW
PRESENCE OF ABNORMAL PIXEL
ABSENCE OF ABNORMAL PIXEL

FIG.23

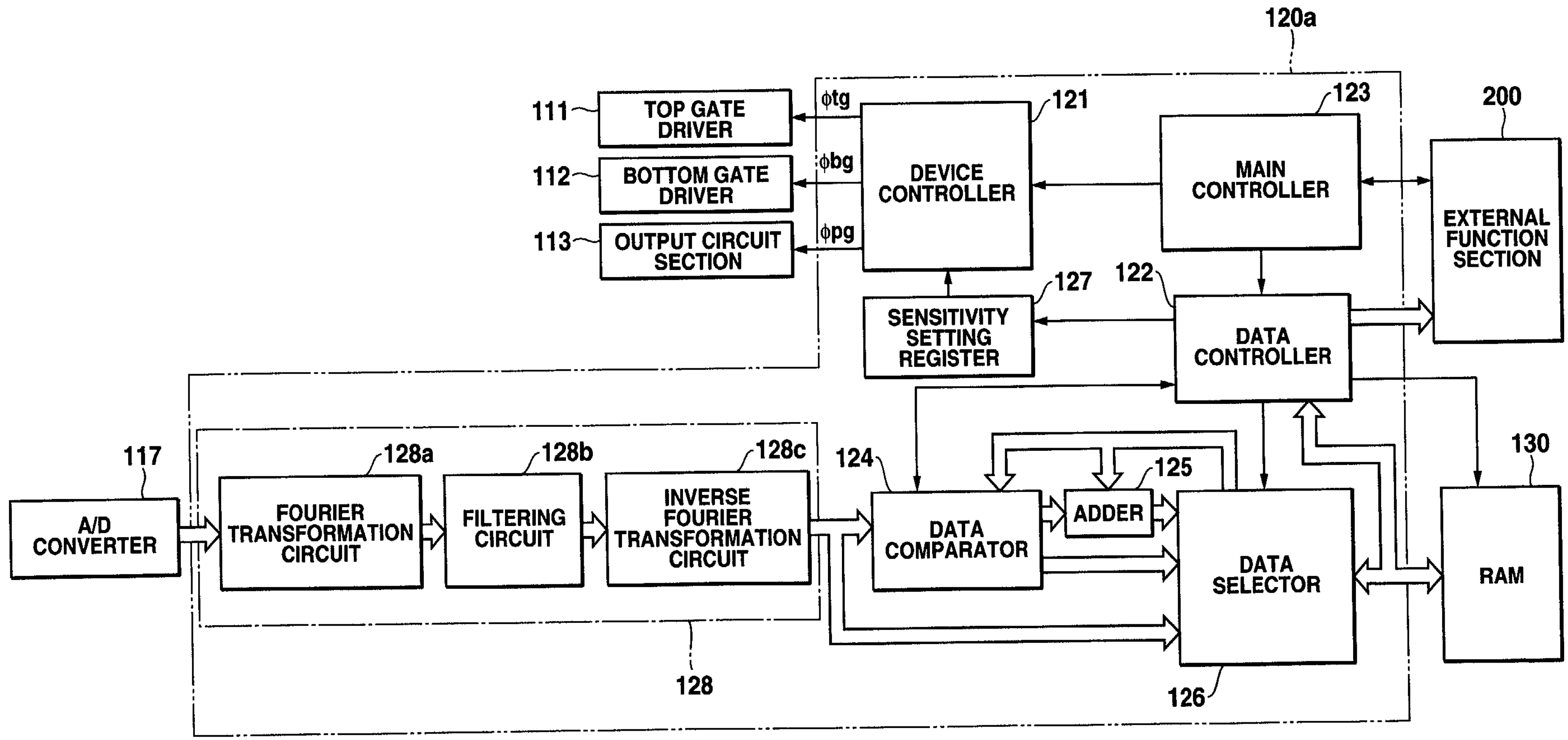

120a
111
TOP GATE DRIVER
112
BOTTOM GATE DRIVER
113
OUTPUT CIRCUIT SECTION
φtg
φbg
φpg
121
DEVICE CONTROLLER
123
MAIN CONTROLLER
200
EXTERNAL FUNCTION SECTION
127
SENSITIVITY SETTING REGISTER
122
DATA CONTROLLER
117
A/D CONVERTER
128a
FOURIER TRANSFORMATION CIRCUIT
128b
FILTERING CIRCUIT
128c
INVERSE FOURIER TRANSFORMATION CIRCUIT
128
124
DATA COMPARATOR
125
ADDER
126
DATA SELECTOR
130
RAM

FIG.24

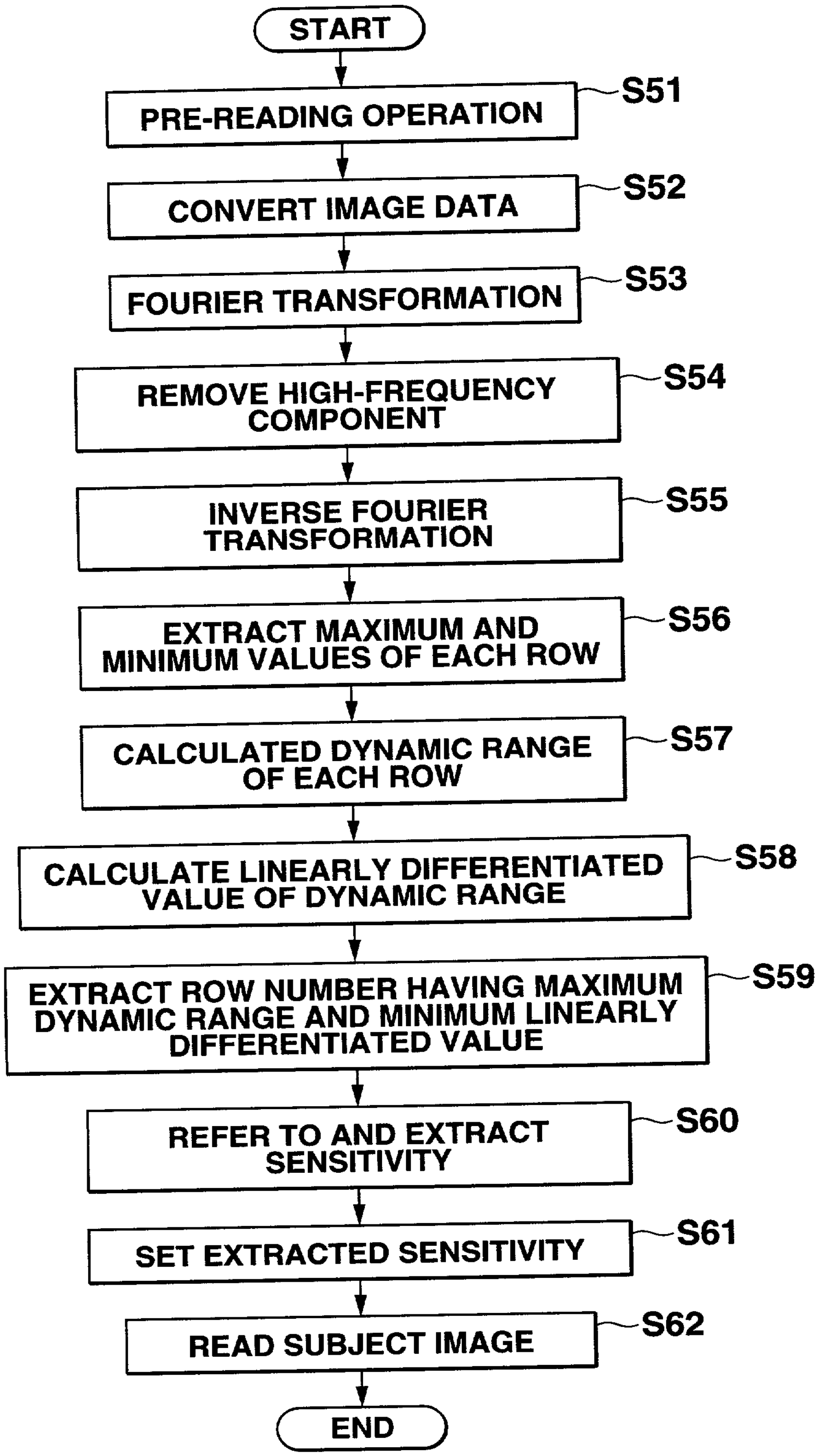

START
PRE-READING OPERATION
S51
CONVERT IMAGE DATA
S52
FOURIER TRANSFORMATION
S53
REMOVE HIGH-FREQUENCY COMPONENT
S54
INVERSE FOURIER TRANSFORMATION
S55
EXTRACT MAXIMUM AND MINIMUM VALUES OF EACH ROW
S56
CALCULATED DYNAMIC RANGE OF EACH ROW
S57
CALCULATE LINEARLY DIFFERENTIATED VALUE OF DYNAMIC RANGE
S58
EXTRACT ROW NUMBER HAVING MAXIMUM DYNAMIC RANGE AND MINIMUM LINEARLY DIFFERENTIATED VALUE
S59
REFER TO AND EXTRACT SENSITIVITY
S60
SET EXTRACTED SENSITIVITY
S61
READ SUBJECT IMAGE
S62
END

FIG.25

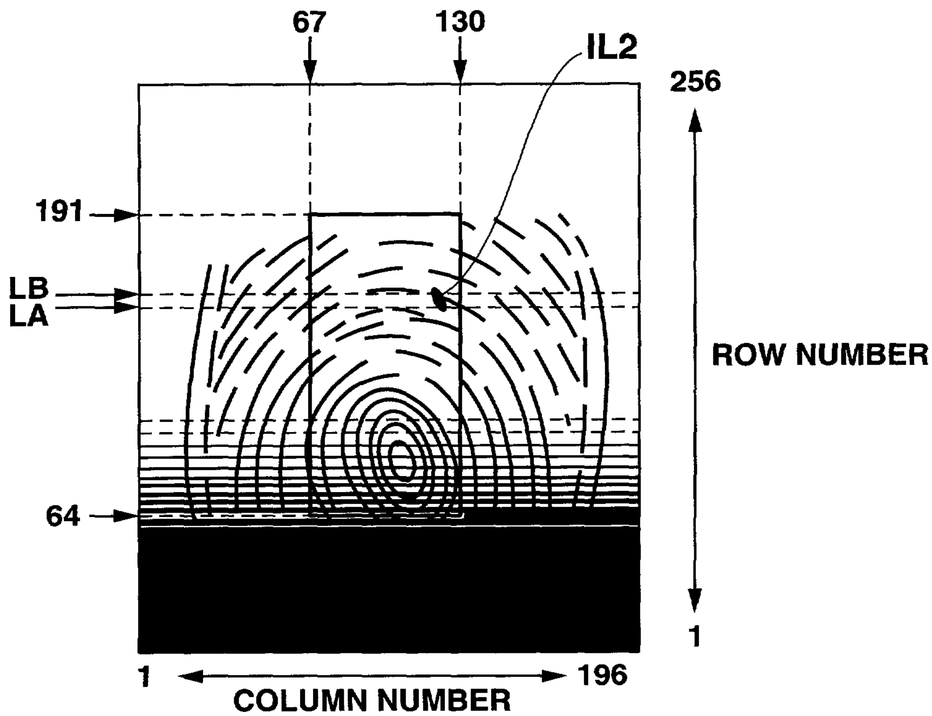


FIG.26

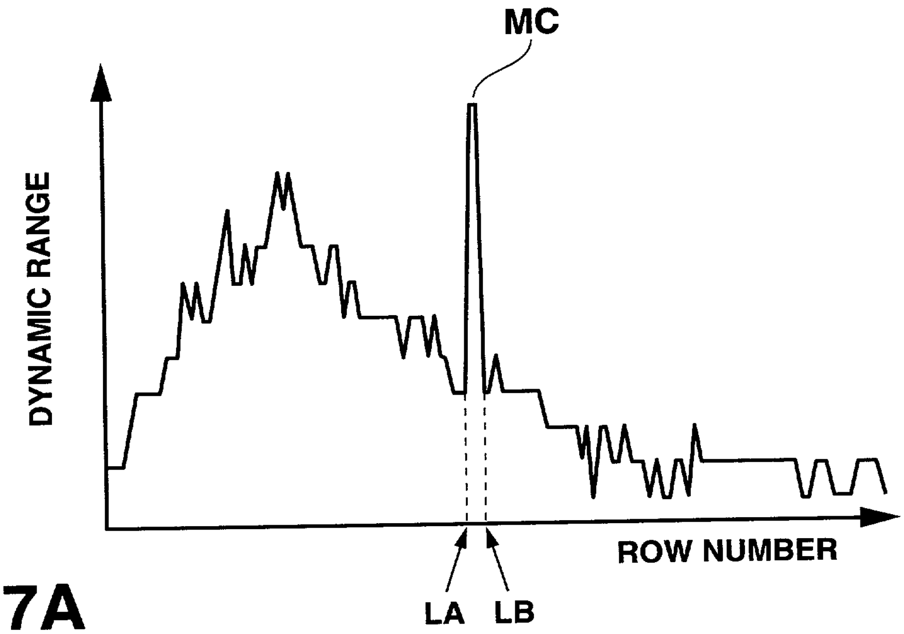


FIG.27A

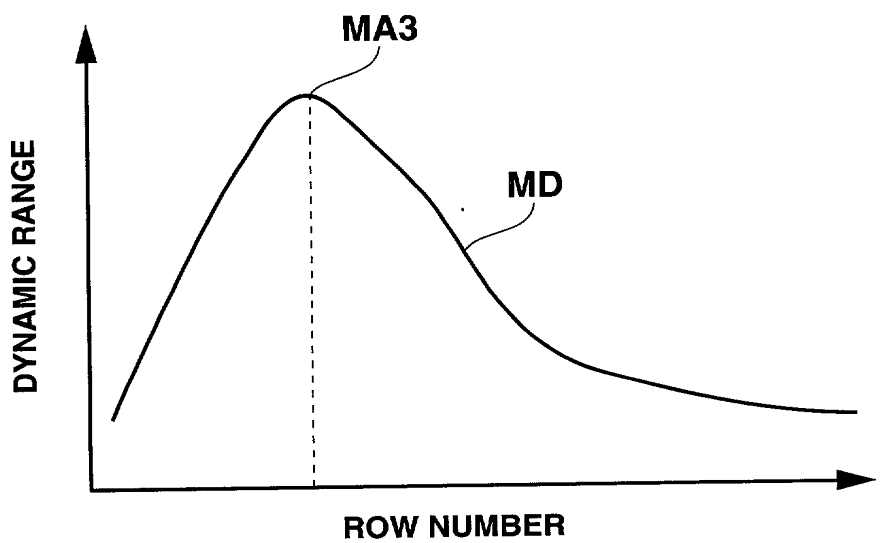


FIG.27B

FIG.28A

FIG.28E

FIG.28B

FIG.28F

FIG.28C

FIG.28G

FIG.28D

FIG.28H

FIG.28I

FIG.28J

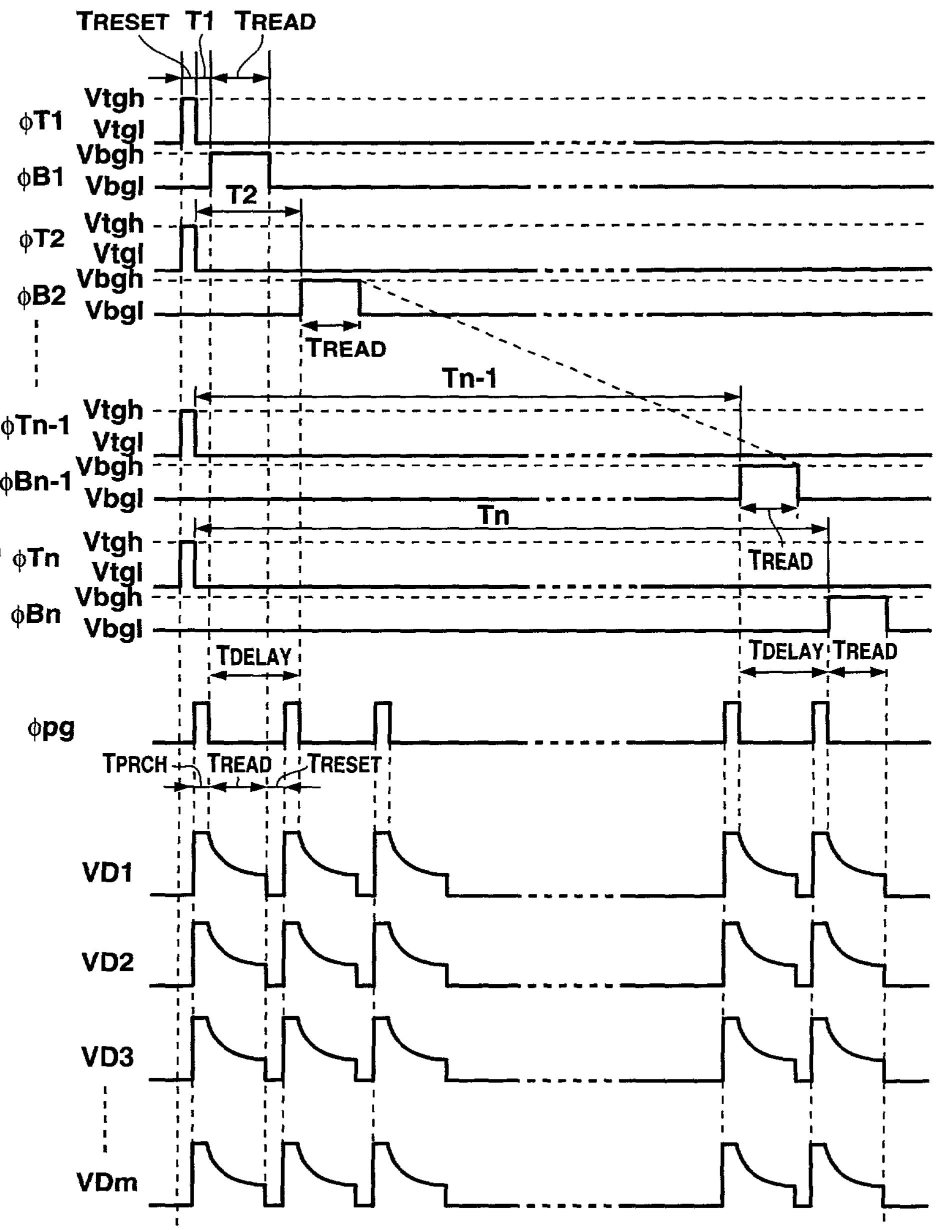


FIG.29A
FIG.29E
FIG.29B
FIG.29F
FIG.29C
FIG.29G
FIG.29D
FIG.29H
FIG.29I
FIG.29J

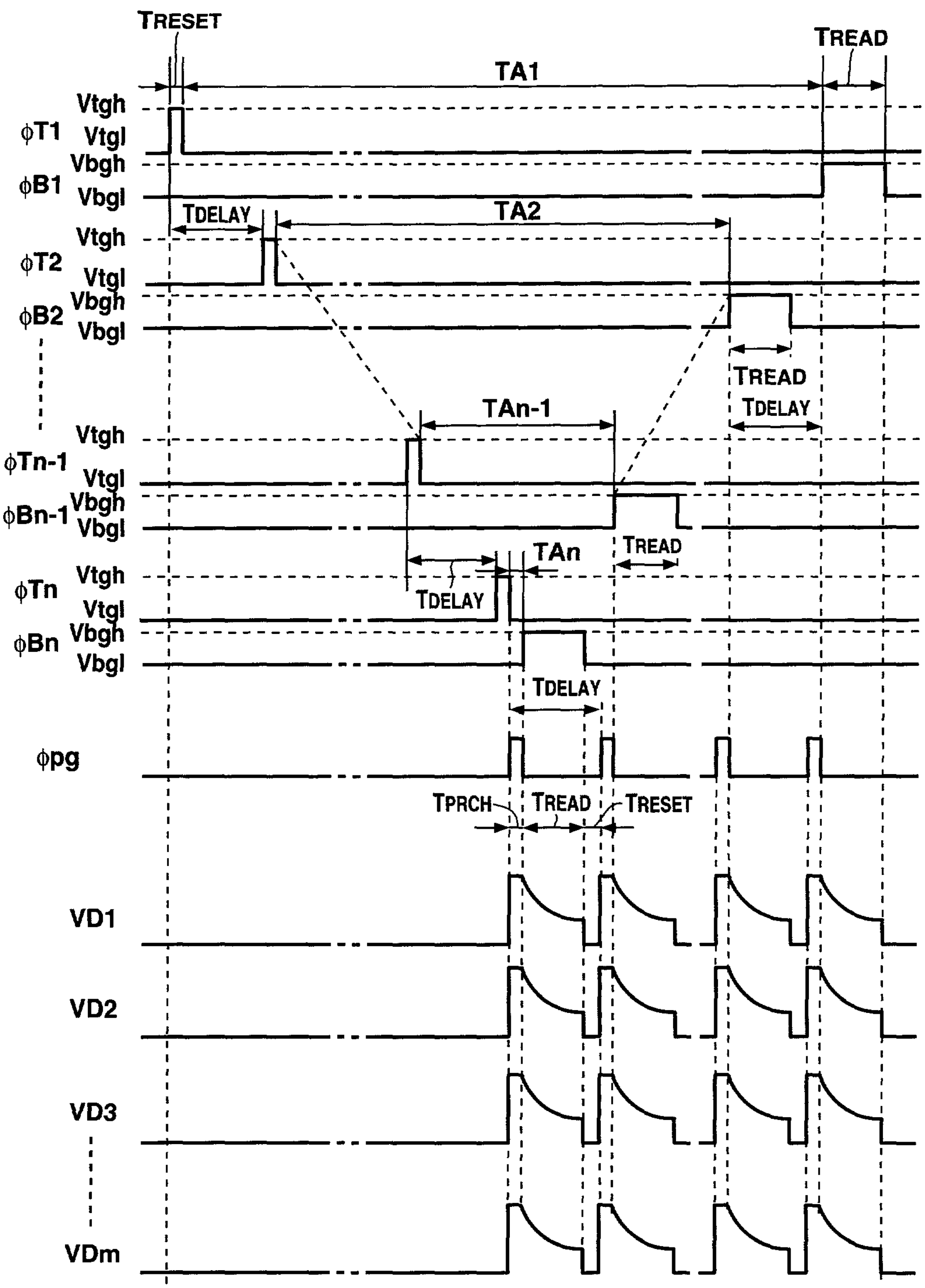
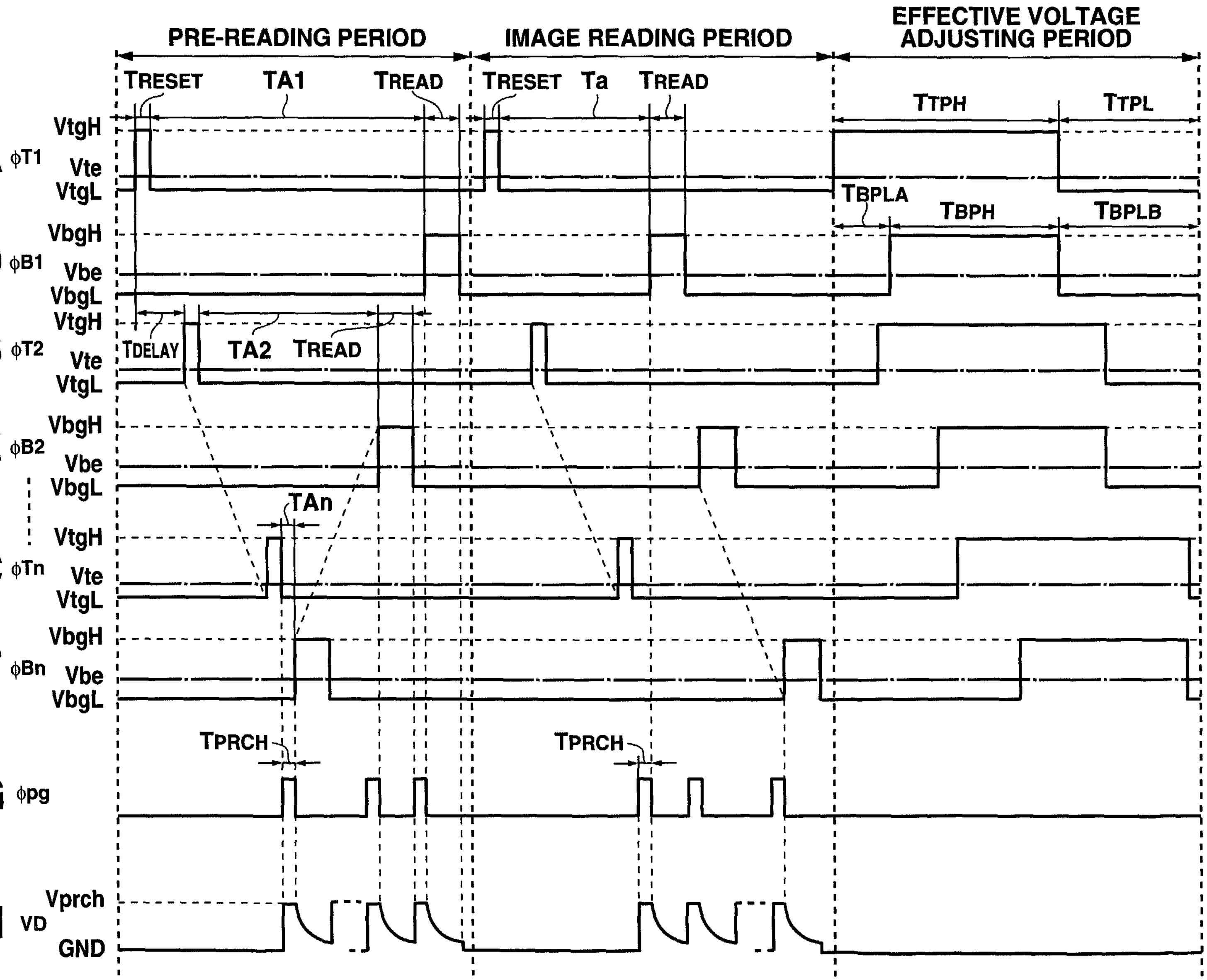


FIG.30A
FIG.30D
FIG.30B
FIG.30E
FIG.30C
FIG.30F
FIG.30G
FIG.30H



PRIOR ART

FIG.31A

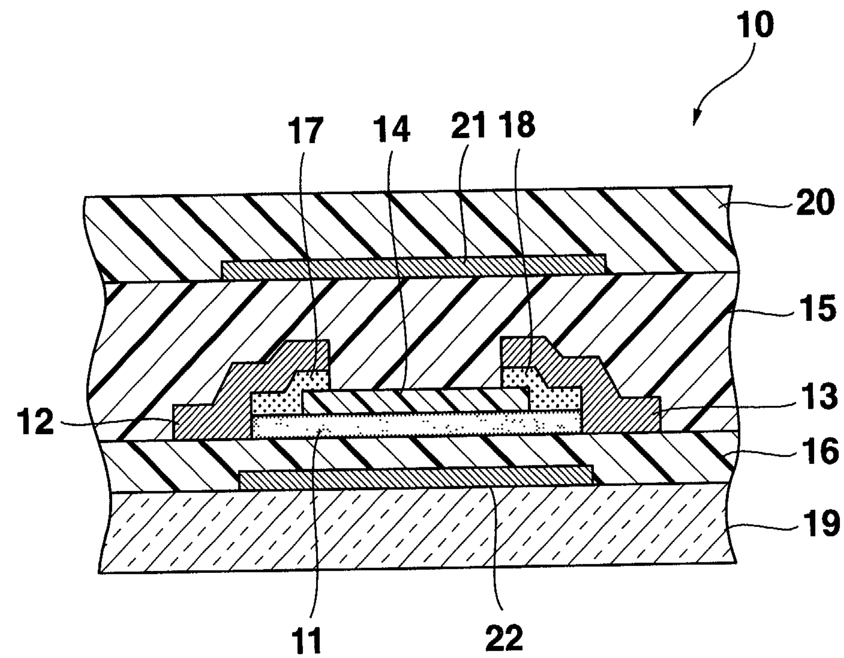
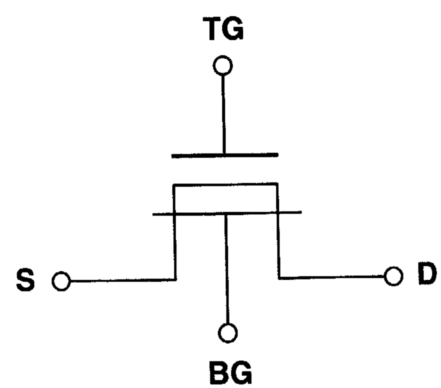


FIG.31B



PRIOR ART

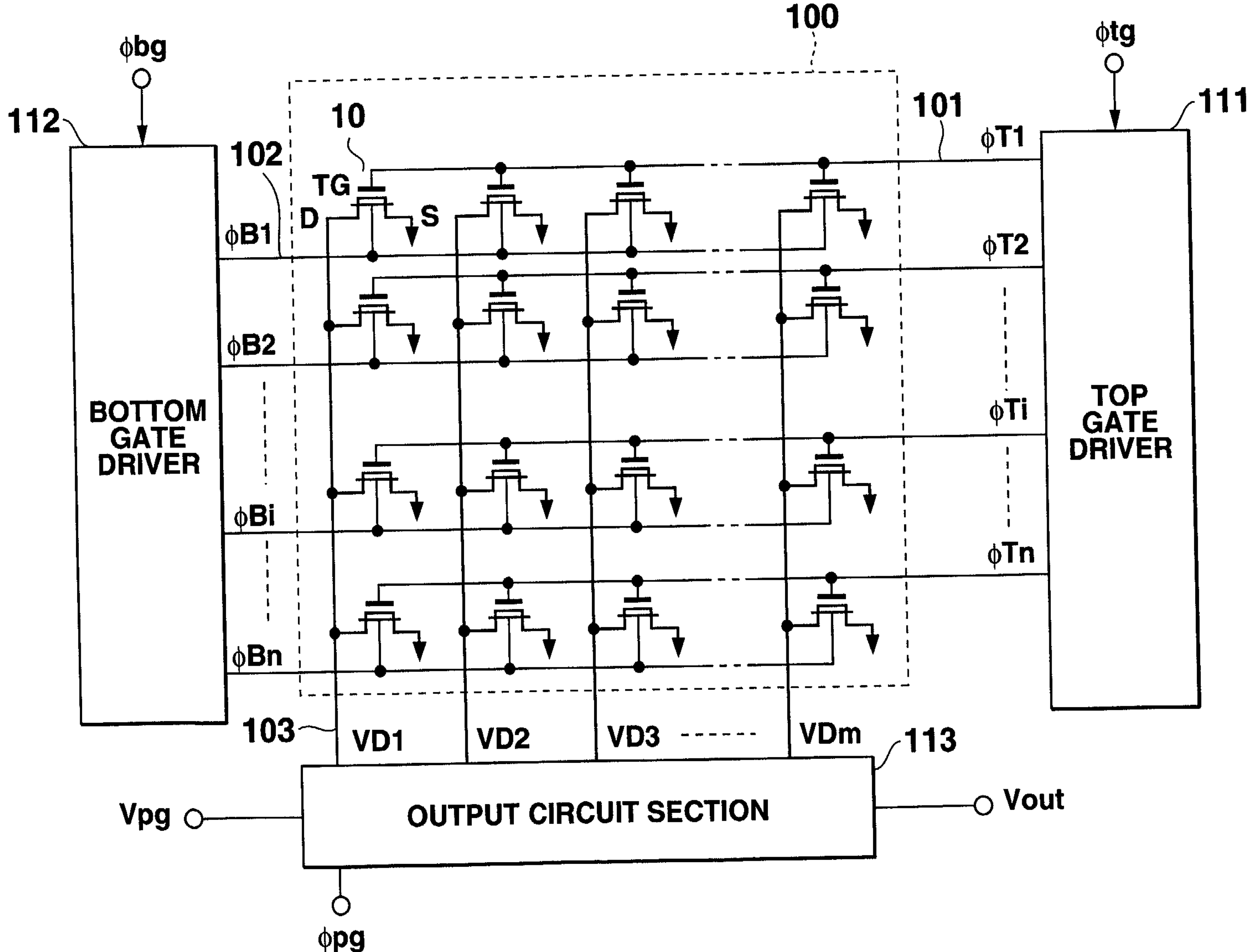


FIG.32

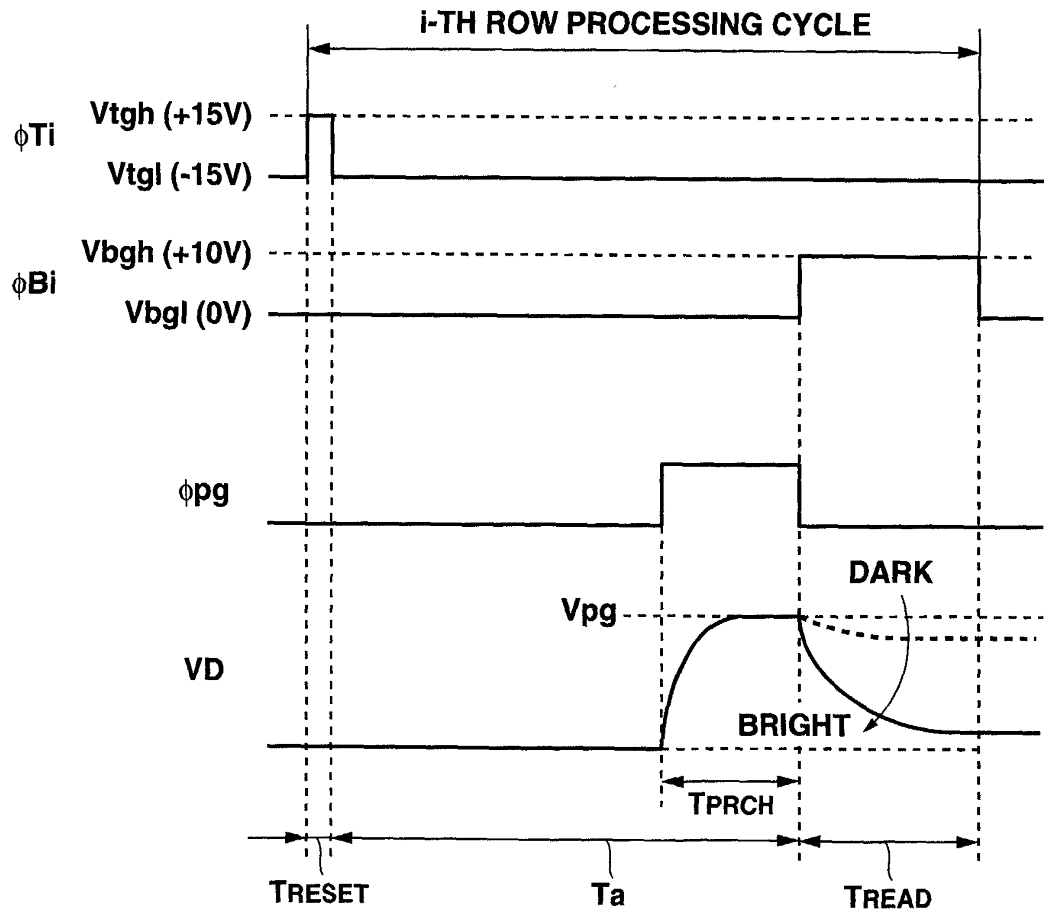
PRIOR ART

FIG.33A

FIG.33B

FIG.33C

FIG.33D



DECLARATION FOR PATENT APPLICATION

As a below named inventor, I declare:
that I verily believe myself to be the original, first and sole (if only one individual inventor is listed below) or an original, first and joint inventor (if more than one individual inventor is listed below) of the invention in

PHOTOSENSOR SYSTEM AND DRIVE CONTROL METHOD THEREOF

the specification of which is attached hereto unless the following box is checked.

☐ was filed on ____________________ as United States Application or PCT International Application No.________________, and was amended on ____________________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
I acknowledge the duty to disclose information of which is material to patentability as defined in 37 CFR 1.56.
I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365 (b) of any foreign application(s) for patent or inventor's certificate, or 35 U.S.C. 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Country	Category	Application No.	Filing Date	Priority Claim
Japan	Patent	11-316650	November 8, 1999	Yes
Japan	Patent	11-319605	November 10, 1999	Yes
Japan	Patent	2000-015981	January 25, 2000	Yes

And I hereby appoint Leonard Holtz (Reg. No. 22,974), Herbert H. Goodman (Reg. No. 17,081), Thomas Langer (Reg. No. 27,264), Marshall J. Chick (Reg. No. 26,853), Richard S. Barth (Reg. No. 28,180), Douglas Holtz (Reg. No. 33,902) and Robert P. Michal (Reg. No. 35,614) each of whose address is 767 Third Avenue - 25th Floor, New York, N.Y. 10017-2023, or any one of them, my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent & Trademark Office connected therewith, and request that correspondence be directed to Frishauf, Holtz, Goodman, Langer & Chick, P.C., 767 Third Avenue - 25th Floor, New York, N.Y. 10017-2023.

I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

00S0172-1

DECLARATION FOR PATENT APPLICATION

I declare further that my citizenship, residence and post office address are as stated below next to my name:

Inventor: (Signature)	Date	Residence and post office address
Yoshiaki Nakamura Yoshiaki Nakamura	Date: October 26, 2000 Citizen of: Japan	9-7-1-5-402, Kabemachi, Ome-shi, Tokyo, Japan
Yasuo Koshizuka Yasuo Koshizuka	Date: October 26, 2000 Citizen of: Japan	1448-1-221, Kumagawa, Fussa-shi, Tokyo, Japan
	Date: Citizen of: Japan	
	Date: Citizen of: Japan	
	Date: Citizen of: Japan	
	Date: Citizen of: Japan	
	Date: Citizen of: Japan	
	Date: Citizen of: Japan	